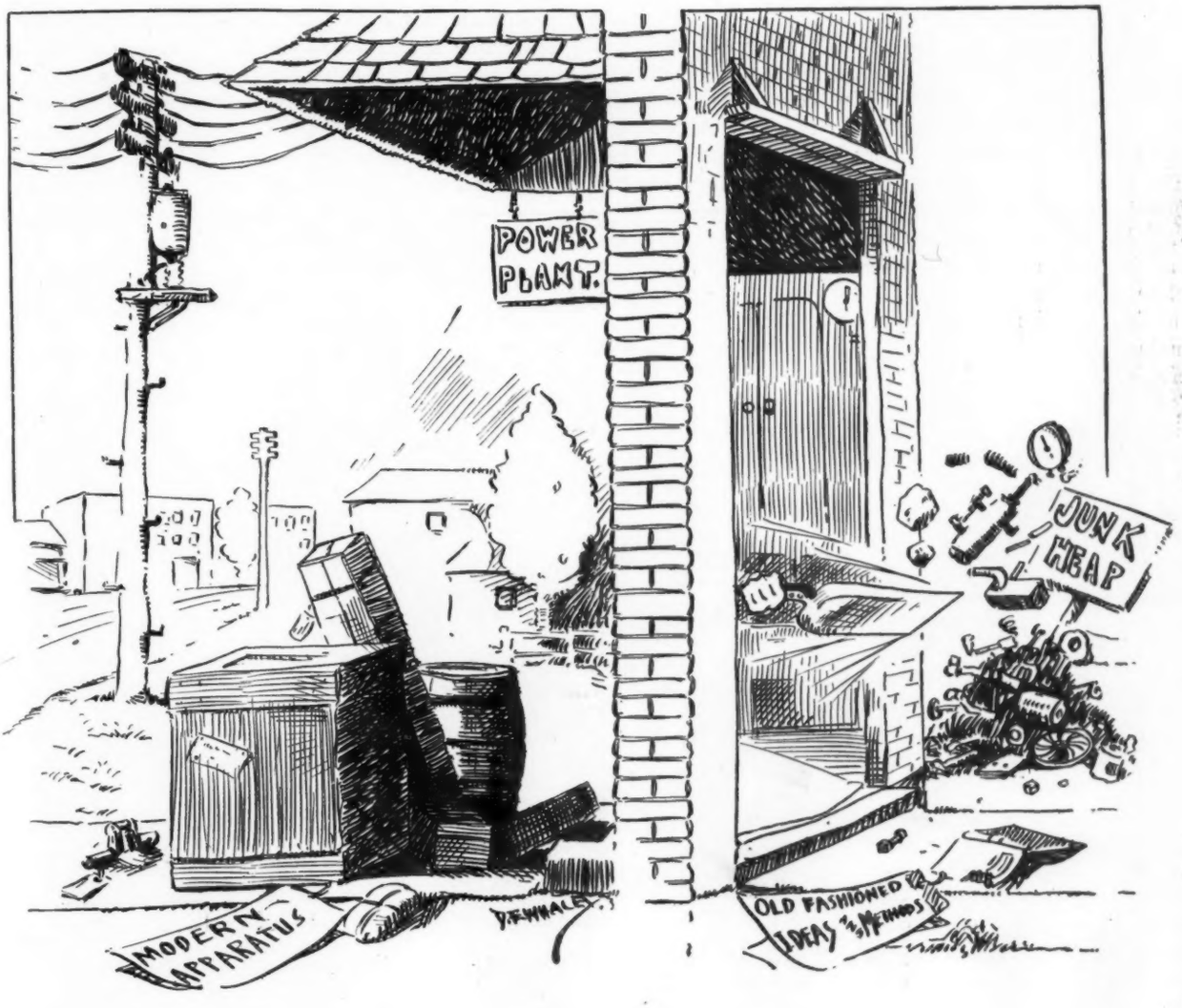
POWER

Vol. 42 NEW YORK, AUGUST 10, 1915 No. 6

A Good Power Plant Motto "Keep Moving"



It Is Sometimes Saving To Throw Away

Panama-Pacific Exposition--I

By F. R. Low

SYNOPSIS—A glance through the most artistically beautiful of all the international expositions. Its plan, significance and symbolism.

San Francisco is situated at the northern end of the peninsula that separates San Francisco Bay from the Pacific Ocean, as shown in the bas-relief panel in Fig. 1. The northwestern point of this peninsula forms the southern side of the Golden Gate. To the south and east of this point is the Presidio Reservation of the Federal Government, and adjoining this at about the middle of the crown of the peninsula are the grounds of the Panama-Pacific Exposition, two and a half miles in length by an average of about a half-mile in width easily accessible by numerous trolley lines from downtown San Francisco (their position relative to which is shown by the map) and by ferry from Oakland and other cities upon the bay.

The arrangement of the grounds and the location of the principal buildings are shown in a second map, Fig. 2. The main buildings are set in the center of the space in a rectangular group flanked by the Fine Arts Palace upon the left and the Machinery Building upon the right. The Court of the Universe is in the center, the Tower of Jewels in front of it upon the face line of the main group, and in front of that a broad plaza, flanked on either side by the South Gardens, leads to the main entrance. At the western, or Presidio, end are the foreign and state buildings, the livestock exhibits and the stadium; at the right the Zone, as the aggregation of amusement concessions is called.

There has been no attempt, as at Paris, to make the main entrance imposing, but it is unique and characteristic of this land of verdure—a living wall of the green mosslike ice plant, or mesembryanthemum, full twenty feet in height and over a quarter of a mile long, broken by simple arches for the turnstiles, as shown in Fig. 3. This plant in blossom becomes a mass of lavender bloom, which is already breaking out upon some parts of the surface, and if it attains the completeness shown in some of the terraces of private gardens hereabout, will be a sight for the later visitor. Its effect in the main wall broken only by occasional rectangular and arched doorways is shown in panel II of Fig. 4. There are no tickets. One must "have the exact fare ready" and pay as he enters; but change booths outside of the gate will split up a gold or silver certificate into an equivalent amount of the "real money" here current.

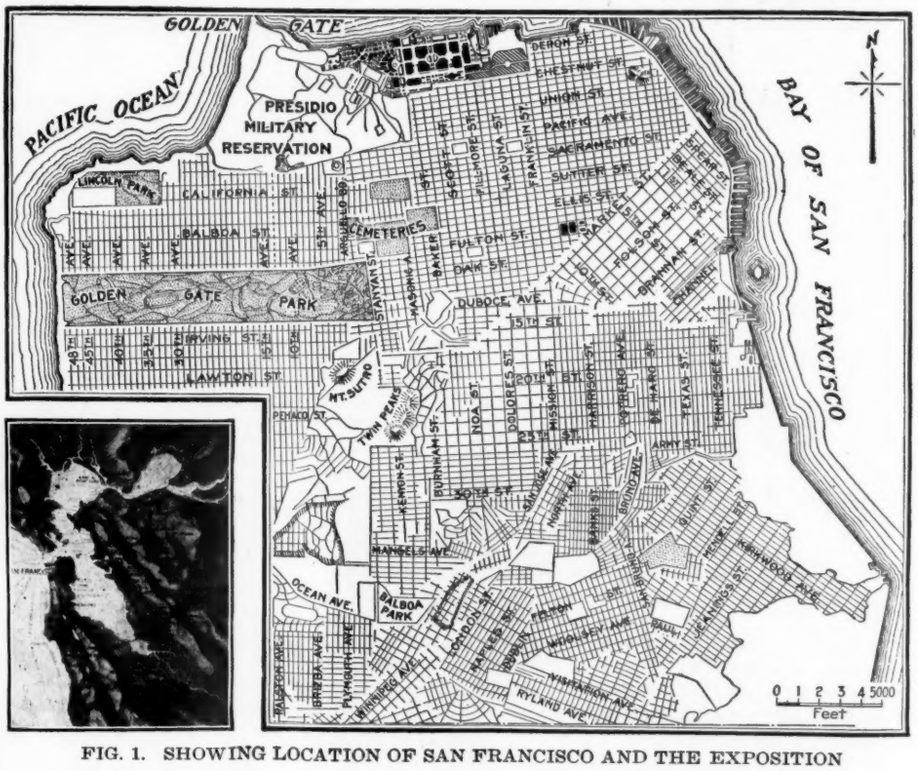
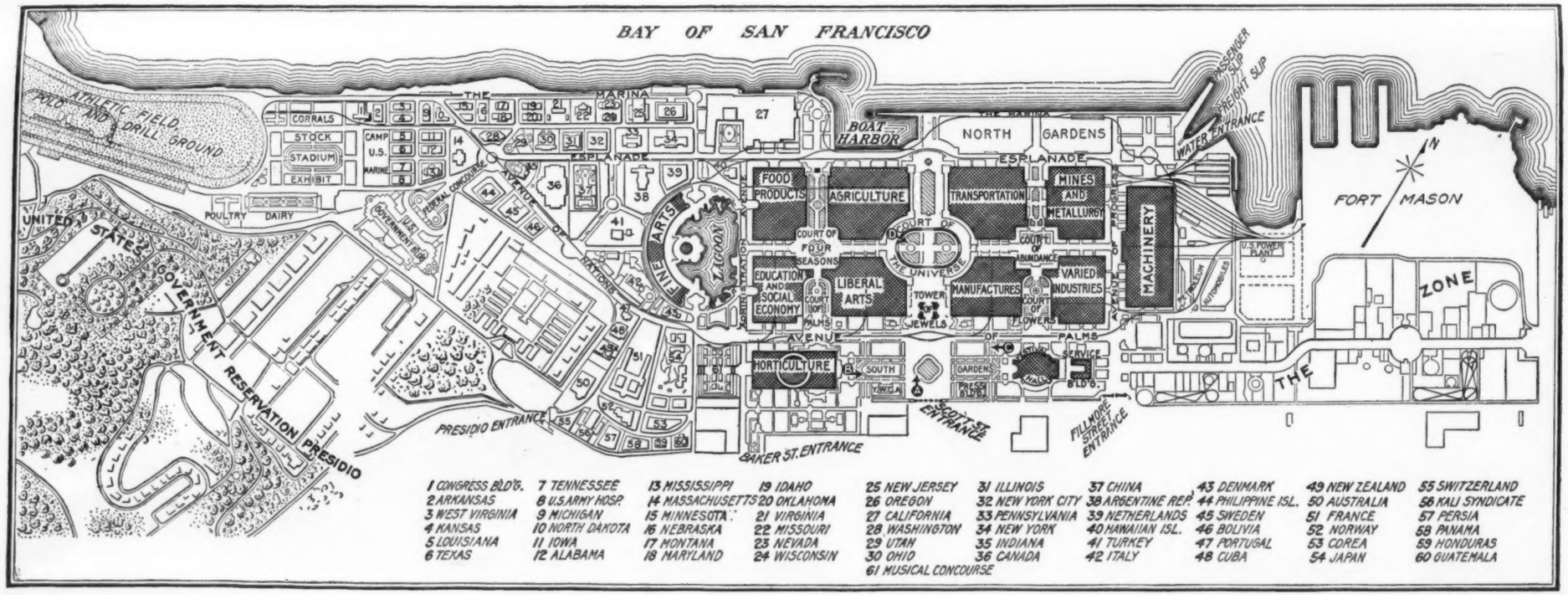


FIG. 1. SHOWING LOCATION OF SAN FRANCISCO AND THE EXPOSITION

America, western America, is not looked upon exactly as an art center, but she has beyond contradiction produced the most artistically beautiful of the great international expositions. When it was given out that the white stucco first used at the World's Fair would take on varied hues, and that there was to be a Tower of Jewels hung with myriads of cut-glass brilliants, emeralds, rubies, topazes, etc., the impression arose that it was to be a riot of color—gaudiness gone gay. The visitor will find no such a thing. The setting of the main exposition is exquisite, restful, harmonious, beautiful, with none of the glare of the White City and utterly void of violent color effects. This is the first exposition which has had a real color scheme and a real director of color, and Jules Guérin has certainly shown the possibilities of an intelligent and consistent use of color in a setting of this sort. The white staff used in such dazzling masses in former expositions has here been treated to simulate the soft Travertine marble of which the Coliseum and many of the structures of old Rome were built. Its striated grays, pinks and yellows give the facades of the buildings the tone and weather-beaten qualities of really old surfaces and an air of establishment, borne out by the proximity of full-grown trees transplanted bodily and growing luxuriously in ground that two years ago was covered by the waters of the bay. These walls are picked out in the panels, doorways, domes, arches, flagpoles, etc., with subdued reds, greens, oranges and blues. The only brilliant colors are in the bunting and the flowers and foliage which grow here so luxuriantly and which have been so effectively used. Even the globes of the cluster lights are tinged a rich ivory. The lighting is for the most part indirect. No rows of blinding lights a little above the eye level



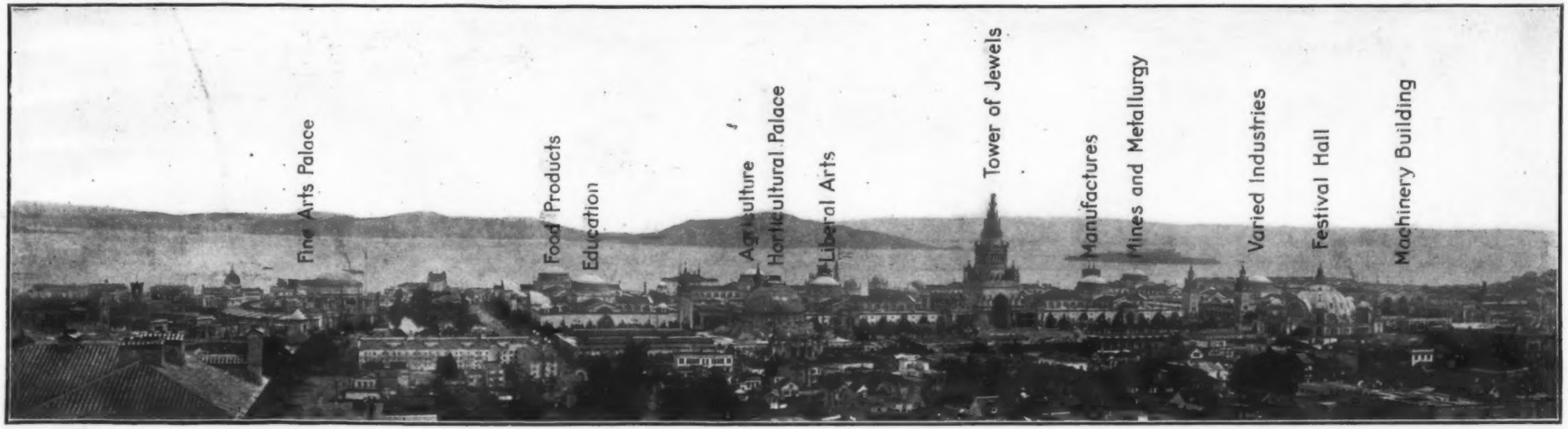


FIG. 2. MAP AND GENERAL VIEW OF THE PANAMA-PACIFIC EXPOSITION AT SAN FRANCISCO

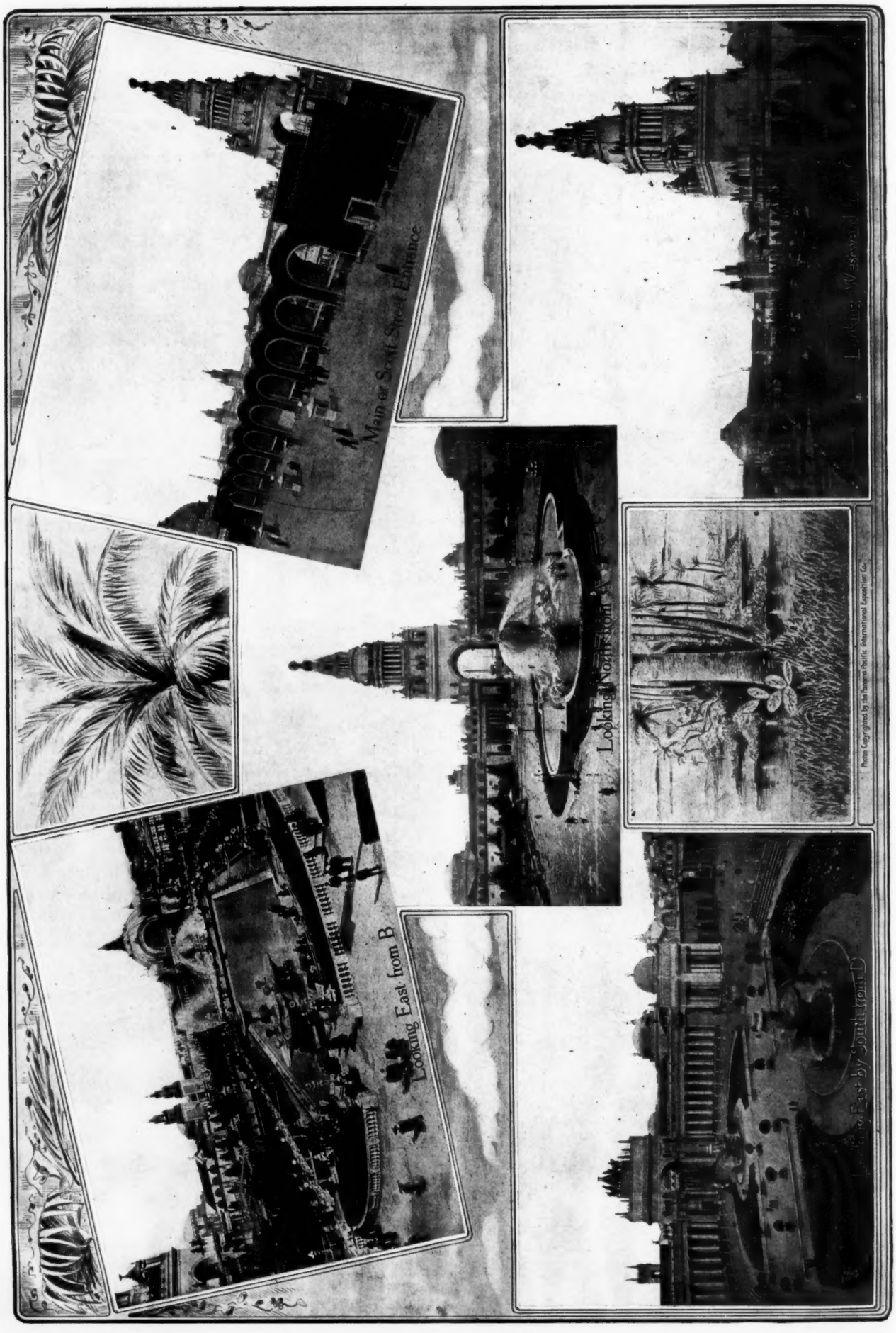

Looking East from B
Looking East by South from D
Looking Northeast from A
Looking Northwest from C
Main or South Side Entrance
Photos Copyrighted by the Panama Pacific International Exposition Co.

FIG. 3. FIVE VIEWS IN THE PANAMA-PACIFIC EXPOSITION TAKEN FROM POINTS INDICATED ON THE MAP, FIG. 2

confine the night view to the avenues. No long rows of white incandescents, except in the Zone, outline the buildings. The main lights are mounted upon high poles, directed upon the buildings and shielded upon the other three sides by ornamental banners, concealing the lamps and giving at night a pleasing lamp-shade effect. The buildings with their sculpture and architectural features stand out as boldly at night as in the daytime, and the indirect light from their surfaces makes the avenues bright without being dazzlingly so. Fixed beams from projectors pick the main groups of statuary out in silvery whiteness against the black of the sky or the green of the foliage, while moving shafts of white light are reflected from the varicolored jewels of the tower. The problem of illumination gave an unbounded opportunity for the display of his skill to Walter D'Arcy Ryan, lighting expert of the General Electric Co., and he has made convincing use of it.

Plan and Grouping of Buildings

This, too, is the first exposition that has had a consistent idea, perhaps that has had the opportunity for the carrying out of a consistent idea, in the grouping of its buildings. The site was practically a waste, much of it under water, when the exposition builders started upon it, and they had free scope. The arrangement of the eight main buildings about a system of courts with connecting arches and colonnades makes it easy for the visitor and gives excellent opportunities to the architect and landscape gardener, besides affording pleasant seclusion and shelter from the winds which are a feature of the locality. The island-studded bay, with Mount Tamalpias and its green foothills in the distance, forms a charming background to vistas through the open-ended courts and avenues. A description would transcend the scope of this article; the photographs reproduced herewith will convey only an inadequate idea. The general view, Fig. 2, taken in connection with the plan of the ground, will enable one to grasp the scheme and identify the principal buildings, in appearance as well as in location. The central panel in Fig. 3 is a view taken from the point *A* on the map looking straight before one as he enters at the main gate, with the Fountain of Energy in the foreground. Panel 1 of the same group, with one of the South Gardens in the center and Festival Hall in the distance, was taken looking east from the point *B* near the Horticultural Palace. They call them all "palaces" here, even the "Palace of Machinery." Panel 5 looks westward from the point *C* toward that (*B*) from which 1 was taken and shows the dome of the Horticultural Palace at the left and the south facade of the main group of buildings, with the Tower of Jewels at the right. Panel 4 is a view from the point *D* on the map, looking east across the Court of the Universe, around which the main buildings are grouped.

Mullgardt's Court of the Ages

Of the courts, that misnamed the "Court of Abundance" is the most effective, though not the largest. It is the conception and work of Louis C. Mullgardt, of San Francisco. He describes it as a historical expression of the world's growth. Reproductions of photographs of it will be found in Fig. 4. The central fountain (panel VII) consisting of a huge globe upon which jets of water are discharged, surrounded by a balustrade in pierced relief, symbolizes the nebulous world with its innate human passions. Out of the chaotic condition came Water (the basin) and Land (the globe) and Light (the sun supported by Helios and the electroliers). At night jets of steam are discharged beneath the globe, so that it appears to be floating upon a cloud, red-tinted by concealed lights. Chaldrons, which in the evening emit lazily floating clouds of vapor, and braziers, to the flaming contents of which are added jets of burning gas from the fangs of serpents bending over them, typify Fire. The floor of the court is covered with Verdure (trees and fruit). The two sentinel columns to the right and left of the tower symbolize Earth and Air. The court is surrounded by an ambulatory elevated above the upper floor level, in the four corners of which are eight mural paintings symbolizing Earth, Air, Fire and Water. The decorative motifs employed on the surrounding arcade are sea plant life and animal evolution. The third stratum, the prehistoric figures surmounting the piers of the arcade, also the first group over the tower entrance, show the earliest forms of animal life. The court is dominated by an Altar Tower on the northern end, the second group upon which symbolizes human struggle for emancipation from ignorance and superstition, in which Religion and War are dominating factors. The torches above these medieval groups symbolize the Dawn of Understanding. The topmost figure of the altar symbolizes Intelligence. The symbols of Learning and Industry are at her feet. The topmost figure surmounting the side altar symbolizes Thought. The facade rising above the dark green of the orange trees is delicately lacy. The effect is rich, mystic, oriental, but to the uninitiated there is no suggestion of "abundance," and it is a shock to see the high priestess with all her retinue of statuary reproduced on the other side of the tower reigning in abated gorgeousness over a minor court.

The Tower and the Model of the Canal

From this eastern court, so suggestive of the ancient and the Orient, one passes on to the large central court through a monumental arch (panel of Fig. 4) supporting a group entitled "The Nations of the East"—Arabian and Mongolian warriors, negro servitors, camels and an elephant with riders, a figure symbolizing the Spirit of the East attended by oriental mystics. Facing this on the other side of the court is a similar arch supporting a group entitled "The Nations of the West," the central figure of which, balancing the huge bulk of the elephant, is a prairie schooner about which are grouped mounted and unmounted figures of Western types, while the hoodah of the elephant is balanced by an ideal female figure extending above the canvas wagon top. One could wish that this Western arch led to a court as subtly suggestive of the new and the West as the "Court of Abundance" is of the East and the old. The setting of the James Earle Frazer's "Lost Trail" here, with a background of shrubbery instead of in the open avenue, with some other typical American statuary, and a suggestion of American types in the facade would have been very effective, symbolically if not architecturally.

In its symbolism the Exposition has made little of Panama. Outside of the model of the canal in the government exhibit and the much larger and operative model exhibited, for a price, as a Zone attraction, there is little to lead the thoughts of the visitor to the great achievement which the Exposition commemorates.

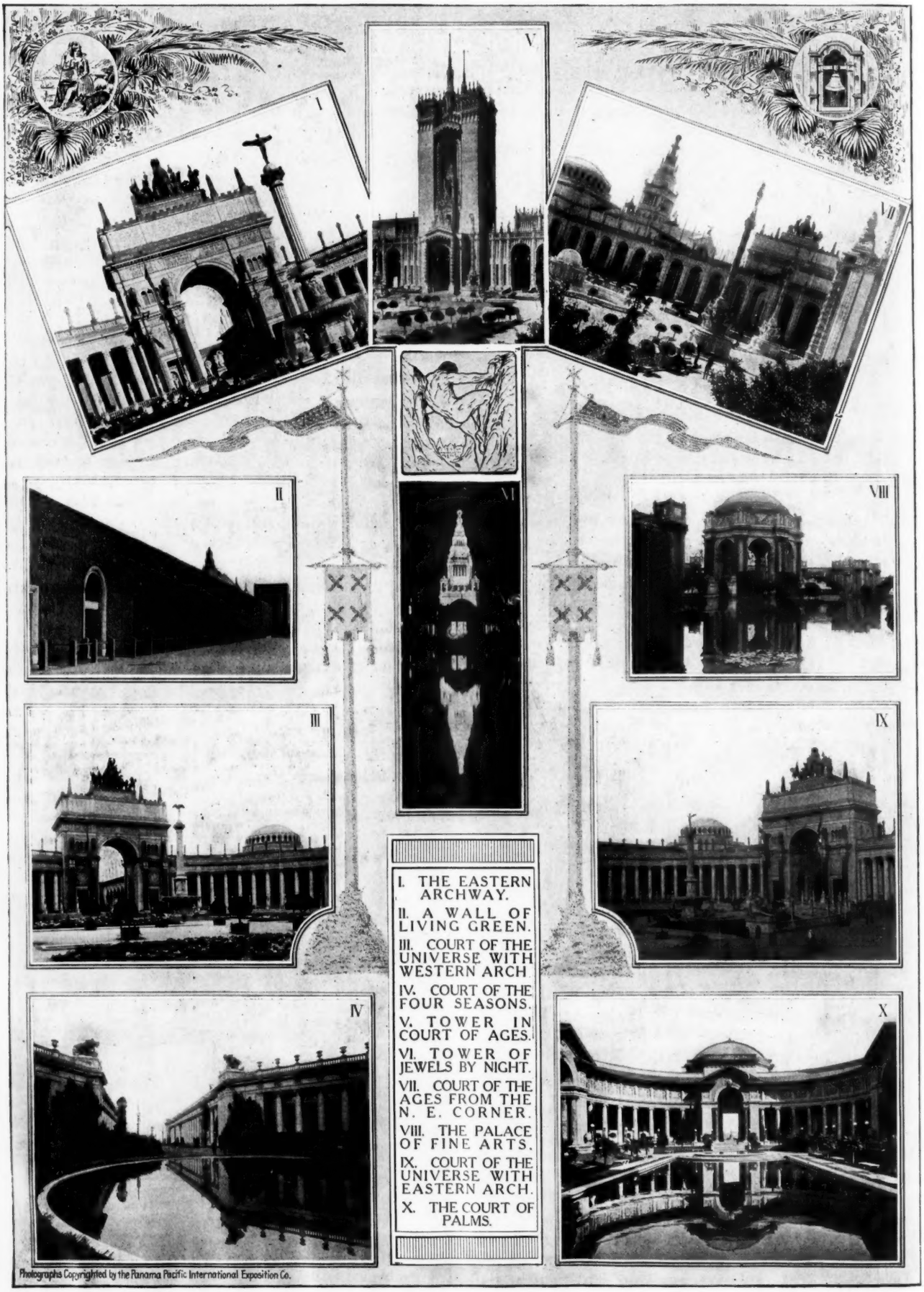

I
V
VII
II
VI
VIII
III
IX
IV
X
I. THE EASTERN ARCHWAY.
II. A WALL OF LIVING GREEN.
III. COURT OF THE UNIVERSE WITH WESTERN ARCH.
IV. COURT OF THE FOUR SEASONS.
V. TOWER IN COURT OF AGES.
VI. TOWER OF JEWELS BY NIGHT.
VII. COURT OF THE AGES FROM THE N. E. CORNER.
VIII. THE PALACE OF FINE ARTS.
IX. COURT OF THE UNIVERSE WITH EASTERN ARCH.
X. THE COURT OF PALMS.
Photographs Copyrighted by the Panama Pacific International Exposition Co.

FIG. 4. SCENES IN AND ABOUT THE PANAMA-PACIFIC EXPOSITION

Operating a Refrigerating Plant

By Thomas G. Thurston

SYNOPSIS—Just what you want to know about running the compression system of ammonia refrigeration. Tells how to take care of the expansion valves, how and why troubles affecting the whole system are produced by improper regulation of these valves. What makes the head-pressure vary and what such variation means to the rest of the plant. The value of good distribution of water over the condenser and how to get it. Lubrication and attention to the oil trap, stuffing-box troubles, and a mint of useful, helpful information for beginners and "oldtimers."

The routine in the average refrigerating plant consists mainly in regulating the water supply to the condenser, watching the stuffing-boxes and adjusting the expansion valves. Of these duties, the handling of the expansion valves is by far the most troublesome, especially for the beginner, and there are many "oldtimers" that are not very proficient. Expansion valves are in many respects similar to the feed-regulating valves on a battery of boilers supplied by a common pump.

Regulating the Expansion Valves

The expansion coil corresponds to a water-tube boiler. To get maximum capacity and efficiency from the boiler the whole heating surface must be in contact with the water; if we allow the water level to get so low that only half the heating surface is in contact, we will cut down the capacity of the boiler. If the water is supplied faster than it will evaporate, the boiler will fill until it primes and carries over into the steam pipe.

The same thing occurs in an expansion coil. If the expansion valve is opened too wide it will flood the coil and liquid will escape into the suction line and come back to the machine. If the valve is not opened enough, only part of the coil is utilized, reducing the efficiency and the capacity of the system.

Going back to the boiler illustration, we are all aware that no two boilers will evaporate an equal quantity of water, even if they are of the same make and size. This holds good with expansion coils even when they are located in the same brine tank. One can seldom get the proper distribution of the feed water by setting all the feed-regulating valves alike; some will be wide open and some will be nearly closed. This applies to the setting of the expansion valves.

To get maximum capacity and efficiency from the system, each coil should be kept filled so as not to let any, or the least possible quantity, of the liquid escape into the suction line.

There is generally a wide variation in the liquid level in the coils from the boiling of the liquid. This can readily be demonstrated by taking a long glass tube closed at one end and partly filling it with liquid ammonia. Placing it in a vessel filled with brine or water, as the ammonia boils the level will rise and fall with the violence of the ebullition; this variation is multiplied many times in the average expansion coil.

Where there are many valves in the system it is impossible to set them all so that each will work to the best advantage, because there is no practicable method by which it can be accurately determined what each is doing. About the best indication is the frost line on the suction stop valve at the end of the coil. The quantity of frost on each coil should be about the same. The sound of the liquid passing the expansion valve will give an approximate idea of what is going into any coil in comparison with the others, but it will not help determine whether the coil will evaporate it, or if it can take more.

To adjust the valves properly, the suction pressure, the frost line on the suction side of the machine and the temperature of the discharge, as well as the frost line on the suction valves on the individual coils and the sound of the expansion valves, must all be taken into consideration. For a given temperature in the coolers and a given speed of the machine, there is a certain maximum advantageous back-pressure. The frost on the suction line should follow back to the machine and the discharge line should be hot. To approach this ideal condition as nearly as possible, the operator should experiment with each valve until he comes to a point where opening any one of the valves more will reduce the discharge temperature without increasing the back-pressure. This will take time and patience, but it is well worth the trouble.

To recapitulate: The back-pressure, discharge temperature, and frost on the suction side of the machine indicate what the system is doing; the sound of the expansion valves, and the frost line on the individual suction valves on the expansion coils give an indication of what the individual coils are doing.

Peculiarities of Expansion Valves

In adjusting the valves it is well to bear in mind that those at the end of a header or line will feed fastest for a given amount of opening; this is due to the velocity of the moving volume of liquid, consequently the valves at the end of a line or header should not be opened as much as those nearer the point of distribution.

Some valves have considerable lost motion before they open, and others begin to open at the smallest fraction of a turn of the wheel. Also valves of different makes have different pitch of thread on the stem, therefore the valves will not be adjusted properly by opening them all the same fraction of a turn of the wheel.

Care of the Stuffing-Box

The stuffing-box is apparently a greater cause of grief to the inexperienced operator than the expansion valves. Generally, it is the handling of the expansion valves that is the indirect cause of stuffing-box troubles.

The inexperienced operator generally opens or closes some valves too much. Then the machine freezes or runs hot, and the valves have to be readjusted. Likely he will do too much adjusting and the temperature will go to the other extreme. The packing expands or contracts with variations in the temperature of the machine, and with every change the rod will run hot or the packing will begin to leak, depending on which direction

the change is taking place, and the stuffing-box will require constant adjustment.

Frequent extreme changes in temperature soon take the life out of the packing. The hardest service comes on the front section of the stuffing-box, because the effect of frequent adjustments is first felt at that place. The back of the packing takes time for adjustment, and the pressure changes on the packing are not so marked there as nearer the gland.

Adjustment of a stuffing-box requires its share of common sense. If the rod is in line and not worn too much and not too old and the expansion valves are once adjusted so that the temperature of the machine remains nearly constant, the stuffing-box will require little attention. If the machine begins to warm up, the gland should be slacked off a little; $\frac{1}{16}$ in. at a time, depending on the size of the stuffing-box, should be sufficient unless it has been neglected and has become abnormally tight, when it must be slacked off to normal tension. Remember also that the rod will warm with the machine, irrespective of whether the packing is tight or loose. So do not jump to the conclusion that the packing is too tight because the rod gets warmer.

If the rod continues to heat without a corresponding increase in the machine temperature, the packing is too tight and the gland must be further slacked off. Give the packing a chance to adjust itself, otherwise the part of it nearest the gland will be quickly ruined owing to the extreme changes in pressure applied.

If the machine is running hot and begins to cool, watch the rod, and when it begins to cool, follow up on the packing, a little at a time. With a little practice and application of common sense, this should give little trouble.

Regulating Condenser Water

Regulating the water supply to the condenser is merely a matter of watching the head-pressure. This pressure should be kept as nearly constant as possible. Variations in it change the rate of feed of the expansion valves, and this will in turn affect the suction pressure and the temperature of the machine and tend to upset the whole system.

What Head-Pressure to Maintain

The proper head-pressure to maintain depends on the temperature, quantity and cost of water, and on the cost of fuel. If water is scarce, warm and costs considerable for pumping and fuel is cheap, it is advisable to carry a high head-pressure. If water is of low temperature and plentiful and can be had at small cost for pumping, and fuel is expensive, the head-pressure should be held as low as possible. This matter will have to be determined according to conditions in each plant.

One thing to keep in mind in regulating the water, where there are several condensers supplied by the same pump, is to keep each regulating valve as wide open as possible, choking the least number of valves to get the proper distribution of the water. The writer has seen some systems running with all the valves nearly shut and carrying several times the pressure required at the pump. This is only waste of fuel and extra expense for the maintenance of the pump.

The machine should be run hot enough so that the jacket water is warmer on leaving than on entering. If it leaves at the same temperature water is wasted and the quantity had better be reduced. Sometimes the water is coming out cooler than it went in. This is a waste of both water and refrigeration.

The machine should be run warm enough so that the jacket water is at least lukewarm, and the discharge temperature of the machine should not be much less than 180 deg. F. for a head-pressure of 150 to 180 lb., and 200 to 225 lb. may sometimes show better efficiency.

Lubricating the Compressor

In addition to the regular daily routine, the oil traps should be blown at regular intervals, inspection and tests should be made for leaks, the air and foul gas must be purged out, expansion coils must be kept as clean as possible, and the ammonia must be changed once in a while.

The regularity with which the oil trap must be blown depends on the amount of oil used. The writer does not believe in putting oil in the compressor, for what works in with the rod combined with what is carried around in the system is sufficient. Ammonia is also somewhat of a lubricant. For the rod, about a pint to a quart per day of twenty-four hours, depending on the size of the machine, should be ample. At this rate the oil trap should be blown two or three times per week. If more oil is used the trap should be blown more often. The high-pressure side of the system should be inspected every day for leaks. If there are any bad ones they can generally be heard or smelt. About twice a week test the joints with a sulphur stick. The jacket water, condensing water and brine should be tested about once per week with litmus paper or Nessler's solution.

Purging the System

Purging should be done whenever thought necessary. Too much purging wastes ammonia. If there has been no "pumping down" below atmosphere and no opening of any part of the system, and there is no oil carried around that will vaporize and form foul gas, the system may run for several months without being purged. If there is much pumping down and the system is opened frequently for changes or repairs, it may require purging twice a week. When the head-pressure begins to climb with the same quantity and temperature of cooling water going over the condenser and some of the stands are cold and the rest hot, it is a sign of foul gas or air in the system. The simplest way to get rid of these is to shut off the dead coils and keep the water running over them; let them stand for five or six hours. Then, if individual connections are provided, purge one coil at a time by making a connection from the purge connection on the coil to a pail or other vessel full of water and let the gas escape through the water in the same manner as heating water by letting steam blow into it. As soon as the foul gas is gone and the pure ammonia comes, there will be a crackling sound, such as that caused by the steam in heating water. As long as the water froths and bubbles, the foul gas is escaping. Provision should be made to keep the water renewed constantly; otherwise it becomes saturated with ammonia and will not give indications properly. If there are no individual purge connections, the whole condenser will have to be shut down and purged in the same manner.

Points About Air-Compressor Practice

By R. H. Rowland

SYNOPSIS—Various causes of losses in air-power transmission are discussed and methods suggested for eliminating or diminishing these losses, together with useful information for air-power users and engineers.

Each motive power has its own field of work, for which it is specially adapted; in extensive mining work, however, compressed air has fully demonstrated its superiority over other powers. Early users of compressed air hardly presaged the wonderful development and application of this power, and its useful field is so rapidly and constantly increasing that its future application will unquestionably be wide. It has many advantages over steam under some conditions, the latter not being a convenient motive power to convey far into a mine, whereas compressed air can be transmitted to any place in the workings, readily divided by means of branch pipes, and carried in small quantities to numerous points. The exhaust air improves the ventilation (although this is hardly appreciable in well-ventilated mines), the cold air cools the mine, and quantities of gas can be cleared away by directing the air to it.

For mine haulage it is largely supplanting the steam engine, and electricity is its only serious competitor. These two powers, however, frequently work in harmony, and what one is deficient in, the other supplies, although in some departments of their respective fields no question of competition can arise.

The installation of a compressed-air plant calls for a large initial investment, but once established, it is not expensive to maintain. It also requires extensive surface plant, and to maintain a uniform pressure it is necessary that the generating plant should have a good margin of power and capacity. The first cost of this should not be considered too much, while on the other hand, the work to be done should be well considered, and a plant established of sufficient size, not only to supply the present requirements, but to have ample margin to permit an increase of from 25 to 50 per cent. in air consumption. The installation should be first-class in every item, and in order to minimize the losses, only good workmanship and sound material should be used.

In installing a compressed-air plant the most important items to consider are boilers, compressor, pipes and motor. The sizes and capacities of these depend upon the physical characteristics of the mine and the required output. The fittings and material cannot be given too careful attention and should always be delegated to the engineer, whose experience and knowledge in such installations is the proper guarantee of satisfactory results. Simplicity in design, safety and ease in operation are requisites in all properly installed plants.

In order to properly determine the size of motor and the tank capacity, it is in most cases necessary to work out in foot-pounds the energy for doing this work. The factors entering into this calculation are: (1) Weights of the empty and loaded cars; (2) frictional resistance, which is dependent on the condition of road and rolling stock; (3) grade resistance, which is the severest condition of grade; (4) curve resistance, depending on the sharpness and length of the curves; and (5) the daily output and most desirable size of train. Having determined these conditions, the size of the motor and storage tanks required can be readily determined.

Laws Governing Compression

To intending users of compressed air a knowledge of the laws governing the changes in the temperature, pressure and volume of air should be of value. They are as follows:

Let

P, V and T = The initial pressure, volume and absolute temperature, respectively, of a given weight of air,

and

p, v and t = The final pressure, volume, and absolute temperature, respectively, of a given weight of air;

then

At constant temperature, $PV = pv$ (a)

At constant pressure, $\frac{V}{v} = \frac{T}{t}$ (b)

At constant volume, $\frac{P}{p} = \frac{T}{t}$ (c)

The following formulas apply if air be compressed or expanded adiabatically:

$$\frac{p}{P} = \left(\frac{V}{v}\right)^{1.408} \quad \text{(d)}$$

$$\frac{t}{T} = \left(\frac{V}{v}\right)^{0.408} = \left(\frac{p}{P}\right)^{0.29} \quad \text{(e)}$$

The units of work U required to compress a volume of air V to a volume of air v, or to compress a volume of air V from P to p, are:

1. Adiabatically, that is, without loss of the heat due to compression:

$$U = \frac{PV^{1.408}}{0.408}\left(\frac{1}{v^{0.408}} - \frac{1}{V^{0.408}}\right) \quad \text{(f)}$$

2. Isothermally, that is, at constant temperature,

$$U = PV\ hyp.\ log\frac{V}{v} \quad \text{(g)}$$

When air is compressed adiabatically, the rise in its temperature is an exact measure of the work done upon it; and therefore the units of work required to compress it can be calculated from the increase in temperature. The rise in temperture $t - T$ is given by (e), and the units of work equal this quantity multiplied by the weight of air in pounds by the specific heat of air at constant volume expressed in foot-pounds, namely, 130.2. Thus if W = weight of the air in pounds,

$$U = (t - T)\ W\ 130.2 \quad \text{(h)}$$

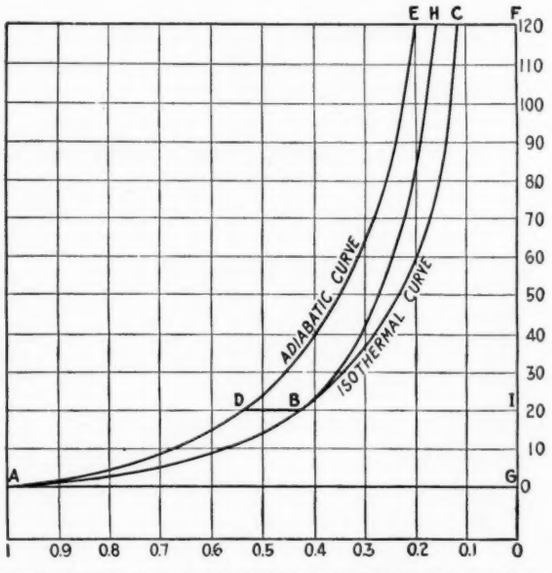
Inasmuch as the causes of loss in the transmission of power by the use of compressed air are of importance,

and in view of the fact that compressed air is used largely in mining operations, it is the writer's intention, after careful study and observations, to summarize the causes and furnish the means of eliminating, or at least diminishing, this loss of power.

Behavior of Air During Compression

It is generally known that when air is expanded it becomes cooler, that its pressure is increased when heated, and that it is cooled when the pressure is reduced; also, that the compression of air (or any gas or steam) is accompanied by a rise in temperature, but specific information regarding the resulting loss of power and the extent to which this heating effect can be neutralized by proper construction and design is not always accessible. There are two limiting conditions under which the compression of air may be accomplished.

Assume that a compressor compresses air at about atmospheric pressure and at 63 deg. F. into one-third of its former volume. It is known that at a constant temperature its pressure would then be 45 lb. absolute and (45 — 15) 30 lb. above the atmospheric pressure. Inasmuch, however, as the temperature is not constant and rises, the compression into one-third volume will in this case actually raise the air temperature from 63 deg. F. to 360. This temperature should therefore give a pressure of about 55 lb. above atmospheric pressure instead of 30 lb., and if the air could be kept at this high temperature, it would remain at this pressure and the result would be perfect, inasmuch as when the air was used in the cylinder it would expand from 55 lb. above atmosphere to the atmospheric pressure, and at the same time would cool from 360 deg. F. to 63. If the heat of compression is removed as fast as generated and the compression proceeds under a uniform temperature, it is said to be isothermal, and the compression curve follows the line *ABC* in the diagram.



ADIABATIC AND ISOTHERMAL EXPANSION CURVES

If this could be accomplished, the air, when used, would give back practically the same amount of work as had been performed upon it in compressing, and if practicable, the heat absorbed from the air by the cooling agent could be applied to the air during its reëxpansion in use along a similar isothermal curve, the result being perfect thermodynamic efficiency. It is toward an approximate realization of these ideal conditions that compressor practice is directed, but in service the compressed air has to be taken a long way in pipes, and since these pipes radiate the heat, the air is correspondingly cooled; and if it should be cooled down to its original temperature (63 deg. F.) while still occupying the same volume, its pressure will have fallen to 30 lb. above atmosphere; and this is what does occur. A loss of heat always results in a loss of work.

In the diagram the line *ADE* represents adiabatic compression, during which no heat is removed from the air and in consequence of which the temperature rises. The result of this rise in temperature is plain; since a given weight of air at a given pressure occupies a volume proportional to its absolute temperature, the volumes at all pressures are greater in abiabatic than in isothermal compression, in a ratio increasing with the pressure; and since the work of compression and discharge is represented by the area in the diagram to the right of the curve along which compression is accomplished, it will be seen that the area *ADECB* stands for the waste of energy caused by allowing the heat of compression to remain in the air.

The efficiency is the percentage which the power given out by the motor bears to the power required to compress the air in the compressor, and the ultimate power developed at the motor is often a small percentage of the power expended. In many cases losses are due to poor design and faulty installation, and the efficiency often may be as low as 30 per cent.; which would perhaps appear misleading and unfavorable if the manner in which the power is used were not considered.

It has been stated by some authorities that the only intelligent way of making comparisons of the efficiency of an air system would be to compare volumes and not horsepowers. Serious losses also arise in the compressor cylinder, and insufficient supply, difficult discharge, defective cooling arrangements, poor lubrication and numerous other causes perplex the designer and rob the owner of power. No loss can be too small to require attention.

Losses in Compression

In adopting recent designs, with all the latest improvements, the cubic feet of air compressed per hour per horsepower has been considerably increased. The power can be transmitted, say at a pressure of 60 lb., two miles distant with an efficiency of about 60 per cent. on the indicated horsepower of the compressor engine, and without reheating. By heating the air this efficiency can be raised to about 80 per cent. With this result compressors have the advantage over electric generators, as they can be run all the time at full load, owing to the ease with which the air may be stored.

The primary causes of loss are: First, generation of heat during compression, which passes away by radiation without producing useful effect; this loss of heat representing an equivalent loss of work. Secondly, during compression, the temperature of the air being increased, its bulk is increased. Also, during compression from atmospheric pressure to 45 lb. above, its bulk is increased so much by the increase in temperature that what should be two becomes three cubic feet in the air cylinder; whereas on leaving it, with reduction again of the temperature, the bulk is again reduced to two cubic feet, so that the compression is performed on a larger bulk of air than

work is obtained from. This is the important point. Thirdly, inability to get full expansion out of the compressed air at the motor. The air on arriving at the motor is at or near the temperature of the atmosphere and always holds some moisture in suspension. On expanding in the cylinder of the motor, its temperature will fall so much that the moisture will freeze and ice will form in the exhaust passage of the engine.

Other causes of loss, or secondary causes, are: Resistance to air in passing through suction and delivery valves, clearance losses in cylinder, leakage past the piston, losses from friction of mechanism, losses in air mains from leakages, and from friction in air mains of too small diameter.

There have been several methods adopted for diminishing the loss of power in compressing air, and the primary losses described above have to some extent been obviated by surrounding the compressor cylinders with cold water, or water-jacketing, so that the surface of the cylinder shall not be heated during compression. This reduces the pressure of the air, and consequently less work has to be done upon it to compress it, and therefore less heat is generated in compression. By this means the temperature is not raised high, and therefore less heat, that is, less work, is lost by radiation during the operation. It is also necessary to cool the cylinders for other reasons, such as lubrication and the packing of the piston rod and valves. Also, when the cylinder is very hot, the air that enters from the atmosphere is at once heated and expanded, before the inlet valve has closed; and thus the air compressed by each stroke will fill a smaller volume when it has cooled in the receiver and pipes. This smaller volume at equal temperature and pressure represents a proportionately smaller quantity of work.

Multi-Stage Compression

Another method is to adopt stage compression with intermediate cooling, which means discharging the air from the cylinder after partial compression has been effected, completely removing the heat generated during the first compression and then compressing to final pressure in another cylinder. This method is called two-stage compression, and when repeated one or more times for high pressures, multi-stage compression.

In two-stage and multi-stage compression the air may be compressed to 35 lb. in the low-pressure cylinder, then passed through the intermediate cooler to the high-pressure cylinder for further compression. For pressures of four atmospheres and upward, the extra first cost, etc., of a stage compressor will pay for itself in a short time, because the loss which arises from heating of the air increases rapidly as the pressure increases. Stage compression reduces these losses.

Cylinder jackets are indispensable in keeping the cylinder walls sufficiently cool for effective lubrication and in the prevention of cumulative heating. At ordinary speeds the indicator diagrams from an air cylinder show a compression line approaching the adiabatic curve much more closely than the isothermal. Diagrams having compression lines deviating considerably from the adiabatic are naturally regarded with suspicion, and leaks through the valves or past the piston may be considered probable.

The chief advantages of multi-stage over single-stage compression are:

1. Lower average temperature, resulting in lower average pressure and permitting the compression of the same volume of air with less expenditure of energy.

2. Increased safety and ease of lubrication. When high final temperatures prevail, part of the lubricating oil vaporizes and wear on the piston and cylinder becomes rapid. Under exceptional circumstances the combination of air and oil vapor may reach the proportions of an explosive mixture, and if the compression temperature passes its flash point, damage may result. Such accidents are rare even in single-stage work; in multi-stage compression with proper intercooling, they are improbable, if not impossible.

3. Greater effective capacity in free air. The final pressure in the low-pressure cylinder is much lower than in the single-stage machine, and the air confined in the clearance spaces when expanded to atmosphere occupies comparatively little space. Consequently, the inflow of air through the suction valves begins at an earlier point in the stroke.

4. The air delivered by a two-stage or multi-stage compressor is drier than that furnished by a single cylinder. Under constant pressure the power of air to hold water vapor decreases with its temperature, and during its passage through the intercooler much of the original moisture in the air is precipitated. Consequently, less trouble is experienced from condensation in the discharge pipe.

Referring again to the diagram and assuming the compression in each cylinder to be adiabatic, the compression curve is represented by the interrupted line *ADBH;* the compression proceeding adiabatically in the first cylinder to *D;* the air then being withdrawn and cooled in a suitable vessel, usually called an intercooler, until its initial temperature is reached and its volume reduced from *ID* to *IB;* with good intercooler arrangements it may be further reduced, being then introduced into a second cylinder and compressed adiabatically, as before, along the line *BH*. The energy required to compress and discharge a given quantity of air under isothermal conditions (perfect efficiency) is proportional to the area indicated by *ABCFG*. The waste energy in two-stage compression (proper conditions, of course, being assumed) is proportional to the two smaller areas *ADB* and *BHC*; while the loss of energy in adiabatic (approximately single-stage) compression is represented by the whole area *ADECB*. The saving effected by constructing the air end for two stages is, therefore, represented by the portion *DEHB*.

Preventing Ice Formation at Exhaust

As it is uneconomical to use air without expansion, some means must be adopted to use it expansively without being encumbered with the freezing difficulty. Several methods have been devised for heating the air before it reaches the motor, so as to obtain the necessary expansion and avoid the freezing. When compressed air is used to drive an engine, the air has already cooled down nearly to its former temperature. When it is expanded in the cylinder down to atmospheric pressure, its temperature falls very low, and thus its pressure on the piston falls much more rapidly than it would if the temperature remained constant. When the air is exhausted its temperature is usually much below the freezing temperature of water, and therefore, the moisture in the air is frozen on the exhaust valves and causes much trouble by chok-

ing them with ice. In the writer's opinion, the best means to adopt to diminish the loss from this cause would be to provide air receivers of a large size, both near the compressor on the surface and near the engines underground, where the air is used; these, together with air mains of ample dimensions, would give sufficient time to deposit moisture, and with large and straight exhaust passages no trouble need be experienced from ice, because if there is no water or moisture, it is not likely there will be ice.

In diminishing secondary losses that may occur by the suction valves not being large enough or the springs upon them being too strong (the negative suction pressure sometimes amounting to 2 or 3 lb. per sq.in.—a serious loss of power), valves actuated mechanically are to be preferred, but these are more suitable for large-sized compressors and are often found to be too great a refinement for small ones.

Attention to Delivery Valves

Delivery valves should be properly adjusted, capacious, easy and quick in action. They should open immediately the piston pressure equals the receiver pressure and should close again immediately it becomes less. In badly constructed compressors the delivery pressure in the cylinders is frequently several pounds below the receiver pressure. Extra work is then required to deliver the air against this resistance. If the delivery valves do not close immediately, the piston pressure becomes less than the receiver pressure and the engine loses the work it has performed. To guard against this the compressor cylinder should be frequently indicated, to see that the valves are in proper working order.

Clearance losses are also troublesome. The simplest method of reducing them is by means of bypass grooves in the end of the cylinder, which allow the high-pressure air to pass to the other side of the piston, where it will be a distinct gain. The air should pass through the grooves at a velocity not exceeding 100 ft. per sec. The piston should, of course, work as close as possible to the cover, so as to reduce the clearance space to a minimum. Only the best kind of piston rings should be used in the air cylinders. The piston of an air compressor is more difficult to keep tight than a steam piston; the moisture from the steam helps to keep the piston ring tight, but the reverse happens with dry air

Losses Due to Mechanical Friction

The losses from friction of mechanism depend chiefly on the accuracy of workmanship, the arrangement of the compressor and the efficiency of lubrication; all of which should be well attended to in the design and future working of the compressor. Equally so, good and reliable workmanship will often result in diminishing the losses from leakage in the air mains. In poor arrangements great loss will result from leakages at the joints of the air pipes, and more care is necessary with these than with steam pipes, because a leakage of steam can easily be seen, whereas small leakages of air cannot. Good joints should be made at first, providing properly for contraction and expansion, and they will give little trouble afterward. The air mains should be sufficiently large. The loss due to friction in air mains increases, not directly as the velocity, but as the square of the velocity. Should the air mains be too small, it is evident that the air will be wire-drawn, the pressure will be diminished, and the greatly increased velocity will produce increased friction. The delivery in the pipes should be more than equal to the quantity that the engines worked are capable of taking out.

When To Use Single- and When to Use Multi-Stage Compressors

The decision of air-power users in regard to the method of compression must be the result of compromise between considerations of first cost and running cost. Below 60 lb. terminal pressure the adiabatic loss is comparatively trivial, and within this limit and at low altitudes single-stage compression is to be recommended. Between 60 and 100 lb. the amount of fuel is usually the determining factor in a choice, though high altitude may also enter the question. Above 100 lb. both safety and economy speak for two-stage, and above 500 lb., multi-stage compressors.

With increase in altitude, the atmospheric pressure decreases from 15 lb. per sq.in. at sea level to about 10 lb. at 10,000 ft. above sea level. Since the density of the air decreases with its pressure, it is obvious that at such altitude the total weight of air handled by a given displacement is considerably less than at sea level; and that to fill any volume with air compressed to 90 lb., a greater free-air displacement will be necessary than would be required at sea level. As the heat generated during compression is dependent upon the number of compressions, and since this number when compressing, for instance to 80 lb., is considerably increased at higher altitudes, it naturally follows that two-stage compression is more imperatively needed at high altitudes than it is at sea level.

Investigation of Fusible Plugs

The failure and deterioration of fusible tin boiler plugs has been investigated by G. K. Burgess, physicist, and P. D. Merica, assistant physicist of the Bureau of Standards. In some instances such plugs have failed to melt and so give warning of dangerous boiler conditions, and investigation has shown that the tin filling in these cases had become oxidized to tin oxide (SnO_2), which has a melting point somewhat above 1600 deg. C. (2900 deg. F.).

About 1050 plugs, of which 100 had been in service, were obtained through the courtesy of the Steamboat-Inspection Service, Department of Commerce, and subjected to examination. This included inspection of design and construction, condition and purity of the tin filling, and, in the case of the used plugs, their classification according to the kind of deterioration undergone by them in service.

One pronounced and dangerous deterioration is the oxidation of the tin along the grain boundaries where there is formed a network of oxide throughout the tin. The plugs showing deterioration of this kind all came from the same manufacturer and contained zinc in amounts varying from 0.3 to 4 per cent. It is shown that this oxidation is due to the presence of this zinc. The latter metal is not soluble in the solid state in tin, and when a tin with small amounts of zinc is heated, as in a boiler, to about 180 deg. C. (340 deg. F.) this zinc coalesces as a network enveloping the tin crystals or grains. The boiler water, particularly if it contains

alkali, will attack the zinc, eating its way into the alloy along the zinc network, and finally form the oxide network described.

Lead and zinc are found to be the principal impurities in tin plug fillings, and since all "failed" plugs contained these or other impurities, the conclusion is reached that if the impurities are eliminated by strict specifications and inspection which will allow only admittedly superior qualities of tin such as Banca and some others, the danger of failures of these plugs will no longer exist.

In order to test quickly the purity of a tin sample a determination of its "freezing" point may be made. This can be done conveniently with two or three grams of the sample and requires only inexpensive apparatus, including a high resistance millivoltmeter and a copper-constant and thermocouple.

Some Odd Experiences with Electrical Machinery

By O. M. Ward

It often happens, when looking for faults in electrical apparatus, that a general survey will save considerable time and money. A good example of this came to my notice some time ago, and no small amount of delay would have been avoided had there been a general investigation at the outset.

The apparatus in this particular case was a 7½-hp. 500-volt compound-wound motor driving a horizontal belt conveying coal to a crusher. The motor was one of several in an entirely new coal-handling equipment, and it was soon observed to be developing an abnormal temperature. Tests were made and the maximum consumption was shown to be 3½ kw. This, to be sure, gave no clew to the cause of the heating, which still continued, and a few days later the fields shorted and grounded. It was necessary to rewind them, but after the motor was put back in service the heating continued as before. Next the armature burned out, an examination indicating no local trouble, but showing the armature completely baked.

In the meantime efforts to locate the trouble had been doubled and one of the manufacturer's representatives arrived, but still no relief was forthcoming. This state of affairs obtained for some time before it was finally discovered that the motor was for intermittent service only and was being operated continuously. A new motor for continuous service has since been installed and is operating satisfactorily.

Dirt Held the Rotor from Turning

A 150-hp. 240-volt three-phase induction motor driving a 100-kw. generator used as an exciter had been in operation for a number of years, when it became necessary to move the set to another part of the building. After all was in readiness in the new location and the starting switch closed, the motor did not start, but gave the characteristic hum of a three-phase motor with one phase open. The wiring was checked up and found to be all right. The operator then attempted to turn the rotor and found that it required the combined efforts of several men on the end of a 10-ft. lever. As the motor had been operating satisfactorily at the time it was taken out of service in the old location, the operator came to the conclusion that the shaft had been bent while the set was being moved; but an examination disclosed the fact that there was no air gap. At any rate, it was impossible to see between the rotor and the stator and a .01-in. feeler could be entered only about 1 in. on either side. However, after several hours' work the feeler was worked through and all around the rotor and the motor then started.

During the time the motor had been operating prior to its removal, it had been about 3 ft. above the main steam header and consequently never reached a temperature much below 90 deg. F. In the new location, however, the temperature was much lower and the grease hardened and "froze" the rotor. This is only one of the many cases where inspection is lax as long as the machine will operate, although with increased energy consumption.

Looking for the Other Man's Trouble

Several times, when the motor of an old-style motor-driven freight elevator was started, the safety brake dropped. It just happened that the voltage was a little low at the time the electrician arrived, and finding everything apparently in good working order, he cut out some of the resistance in the safety-brake circuit and relieved the situation temporarily. The following day, however, similar trouble again developed. This time the electrician decided the trouble was due to the adjustment of the brake and sent for a machinist. The latter could not find anything materially out of order, but, to satisfy himself, began to readjust the brake band. Each time an adjustment was made the main switch was opened, and upon trying the elevator again the operation would be satisfactory for an hour or so only. After spending most of the day on the job, the electrician sent for his foreman, who found the safety-brake magnet to be very weak. An examination of the coil revealed that the winding was badly short-circuited. The coil was rewound, put back in service with the original resistance and operated with entire satisfaction.

That the practice works both ways is shown by the following experience with an elevator of similar construction: The worm gear driving the cable drum had been replaced and the elevator tried out, but instead of starting the motor "flashed over." The machinist immediately sent for an electrician to locate the trouble. The wiring was checked over, found to be all right and the motor tried out, but with the same results as before. The inspector then attempted to turn the motor, but found this to be impossible and located the trouble in the newly installed worm gear. Had this been an engine-driven machine, the first thing to be inspected would have been the part worked on. But with electrical apparatus as the motive power the machinist's usual common sense was forgotten and the job put up to someone else.

Mechanical Efficiency is a term intended to express the ratio of indicated horsepower to that available for doing work. Brake horsepower divided by indicated horsepower gives the mechanical efficiency.

$$\text{Mechanical efficiency} = \frac{\text{B.hp.}}{\text{I.hp.}}$$

For small single-cylinder engines the mechanical efficiency may be as high as 94 per cent. or the friction 6 per cent. of the indicated power. For large compound engines the mechanical efficiency is sometimes as low as 80 per cent. or the friction 20 per cent. of the indicated power.

How to Read a Slide Rule

SYNOPSIS—The article tells in a simple way how to read the numbers and divisions on a slide rule. The student with his rule in hand, is shown how to find values on the rule and how to know those values when he has found them. From simple readings he is gradually acquainted with the reading of values that come between numbered divisions on the rule. He is shown that he can make his rule equivalent to a table of numbers and their squares, or circumferences and diameters of circles. For exercise in reading the rule an assistant having a book with these tables checks the numbers as they are read from the rule by the student.

You cannot learn to play chess by reading a book about it without actually following out the moves with the men on the board. You cannot learn to play the piano by reading the instructions; you must practice.

The first step in learning to use a slide rule is to get a slide rule. On the ordinary or Mannheim rule, shown there are four scales, two on the rule proper and two on the slide, lettered for convenient reference *A, B, C* and *D* as the first figure shows.

Place the left-hand 1 of the C-scale over the 2 of the D-scale, as it is arranged in Fig. 1. Now look at any number on the C-scale and you will see that the number on the D-scale immediately below it is the upper number multiplied by 2. Just as the 2 on the D-scale is twice the 1 which you placed above it, so the 4 on the D-scale is twice the 2 which you will find above it. Under 3 on the C-scale you will find twice 3 or 6, under the 4, 8 and under the 5, 1, or 10, for the slide rules give only the figures without any regard to decimal values and 1 may mean 1 or 10, or 100 or 0.1 or 0.01.

Set the right-hand 1 of the C-scale over the 2 of the D-scale, as shown in Fig. 2. Now under the 6 of the C-scale you have 12 on the D-scale.

Notice that as you go to the right the spaces get smaller. On a 10-in. rule the space between 1 and 2 is nearly 3 in. and its ten main divisions are numbered with smaller figures. Each of these main divisions is again divided into ten parts so that in the space between 1 and 2 there are 100 divisions. The space between 9 and 10 on the other hand is less than one-half inch, and the most that we can do is to divide it into 10 spaces and halve them. These relative spaces are shown in Figs. 1 to 5.

The 6 of the C-scale is now between the main divisions 1 and 2. It is to the right of 1 and is tenths of the divisions over to 2, so the reading is 12.

The divisions in the thirties are the same as in the twenties only smaller, and those in the forties to the nineties inclusive are all alike, getting smaller as they go up in value, as shown by an inspection of the rule.

With the right hand 1 of C-scale over 2 of D-scale continue reading. Under the 7 find 14; under the 8, 16; under the 9, 18 and under the 1, 2; or if you call the top one 10 the under becomes 20.

Now look at 15 on the D-scale; the fifth main subdivision between 1 and 2, marked with a small figure 5. Immediately above it is 7.5, for it is under the middle line between 7 and 8. These middle lines, indicating 5, are made somewhat longer than the others, as is common on other scales to make the reading easier. Put the left-hand 1 of the C-scale back over the 2, as in Fig. 1, and over the 3 of the D-scale you will find 1.5 on the C-scale. Look above 9 on *D* and you will find 4.5 on *C*, which is one-half of 9 as 1.5 is of 3.

Look under 23 on *C* and you will find 46. The 23 is at the third main division beyond the 2 (see arrow, Fig. 1), and the 46 immediately under is indicated by the sixth main division between the 4 and the 5.

Look just above 55 on the D-scale. The reading ought to be ½ of 55 or 27.5. Can you read it? The space between 27 and 28 is divided into five parts, which indicate $\frac{2}{10}$ each. The 55 line is half way between 27 and 28, or at 27.5. It has 2½ of the smaller spaces indicating two each on either side of it.

Place the left-hand 1 of the C-scale over 25 of the D-scale, as in Fig. 3. Now everything on the D-scale is 2.5 times that immediately above it on the C-scale; 2 is over 5, 3 is over 7.5. Look under 25 and what do you read, 6, and 2 main spaces, signifying 1 each and one-half of another such space signifying 5? Hence 6.25, which is 2½x2½.

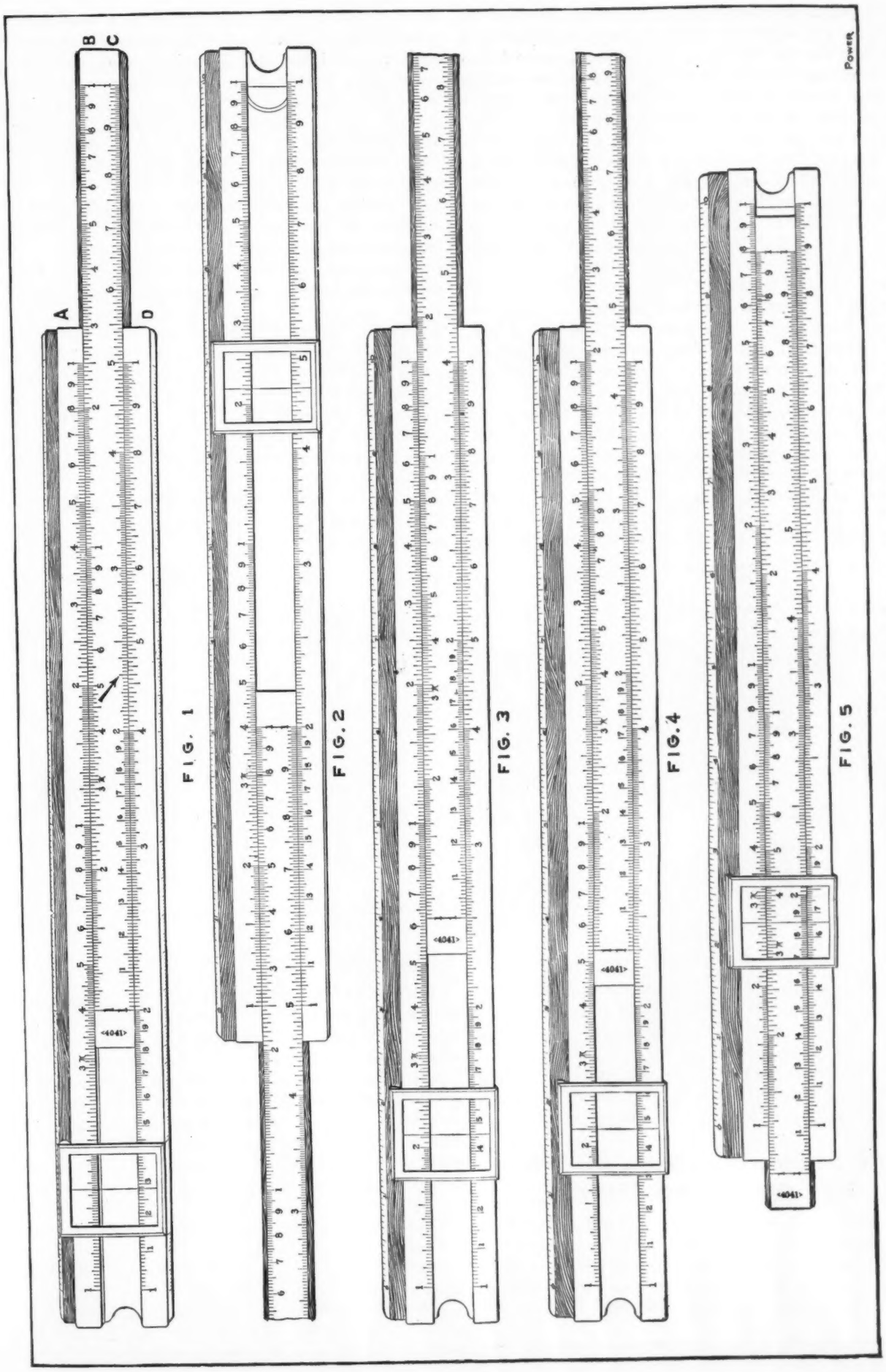
One soon becomes accustomed to the different values of the divisions made necessary by the unequal spacing. The way to get accustomed to them is to keep reading them.

With the rule set on 2½, as shown in Fig. 3, read first the numbers corresponding to the even numbers on $\frac{C}{D}$ $\frac{1}{2.5}$ $\frac{2}{5}$ $\frac{3}{7.5}$ $\frac{4}{10}$ shift the slide (right 1 on 25) $\frac{5}{12.5}$ $\frac{6}{15}$ $\frac{7}{17.5}$ $\frac{8}{20}$. Then read the even numbers on *D*, $\frac{C}{D}$ $\frac{4}{1}$ $\frac{8}{2}$, shift, $\frac{12}{3}$ $\frac{16}{4}$ $\frac{2}{5}$ $\frac{24}{6}$ $\frac{28}{7}$ $\frac{32}{8}$ $\frac{36}{9}$. This can be $\frac{C}{D}$ $\frac{28}{7}$ or $\frac{2.8}{7}$ and $2.8 \times 2.5 = 7$.

You can be sure with this setting that the number below the line is to that above it, as 2.5 (or 25, etc.) is to 1 and that the number above is 4 (or 40, etc.) times that below it, so you can know if your reading is right, and keep on reading until you get it right at a glance. You can soon learn to read a figure from the rule without counting the marks just as you do words in a book without spelling them out.

After you can read from the even numbers on both scales, try reading from the divisions as 25, 325, etc. Go the full length of the scale so that you will become accustomed to reading the small divisions between 9 and 10, one of which is equal to 5 of the small divisions between 1 and 2, as well as the intermediate divisions. When you have any doubt about the value of a division, think what part it is of a tenth of the space.

Now set the left-hand 1 of the C-scale on 23 as in Fig. 4. Everything on the D-scale will now be 23 times that on the C-scale immediately opposite it. Opposite 2 on the C-scale, for instance, we find 46 on the D-scale. Opposite 24 on the C-scale, what do you find? It is little more than 55. The mark on the C-scale for 24 is not quite half-way between the 55 and the 555 mark. We



WITH YOUR SLIDE RULE IN HAND, SET IT AS SHOWN HERE AND AS DIRECTED IN THE LESSON

might judge, therefore, that it was about 552. If we think for a moment that we are multiplying 23 × 24, it is evident that the unit figure must be a 2, because 4 × 3 = 12, so that, although we had an indeterminate reading we have a positive product of 552. The unit figure of any product can be determined in this way.

When you have got well acquainted with your rule in this way, practice the following alone at odd moments: Set 3.14 of the C-scale against 1 of the D-scale. This is the ratio of the circumference to the diameter of a circle. The ratio is 3.14159+, and is designated by π, which is called "Pi." Many rules have a mark upon them so designated to make this much-used setting easy.

Now for any diameter on *D* the circumference will be found on *C*. Your rule has become a table of diameters and circumferences. Get somebody to take a book with such a table in it, call off diameters and see if you can give him the circumferences. Keep at this until you can do it instantly and correctly.

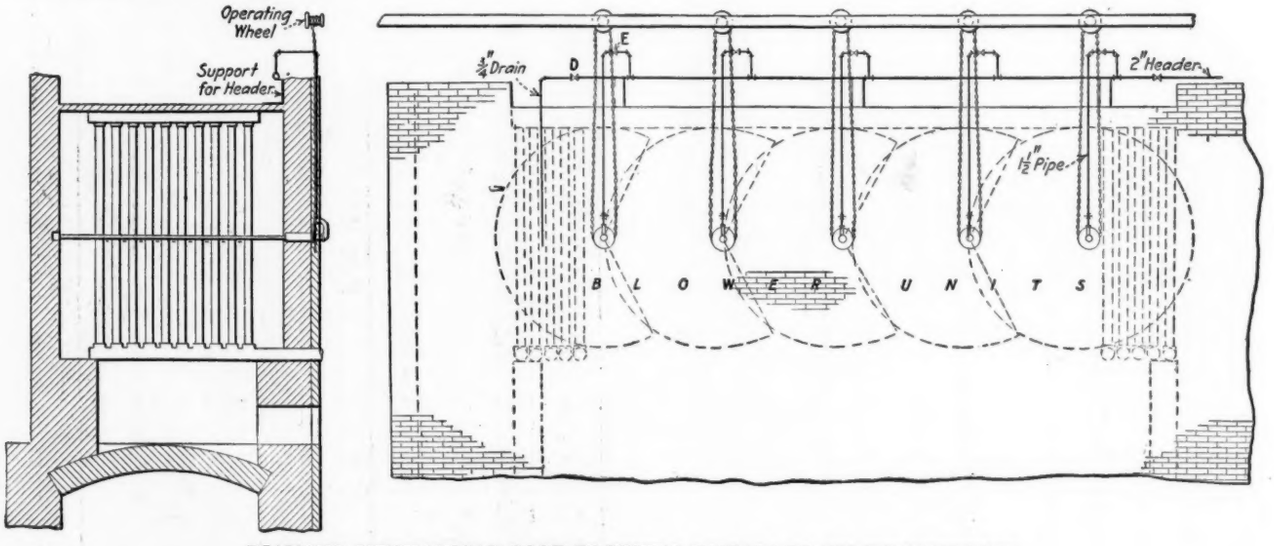
Now set the right-hand 1 of the B-scale against 7854 of the A-scale, as in Fig. 5. There is usually a mark here, too. Now put the hair line of the runner on any number on the C-scale, and you will have under the hair line on the B-scale the square of that number, on the A-scale the area of a circle of that diameter, and on the D-scale the length of the side of an equivalent square; that is, of a square inclosing the same number of square inches that there are in the circle. Let somebody take a table of areas of circles, call off diameters and let you read the areas from the A-scale.

When you have learned to do this quickly and accurately you will have made a big step toward mastering the slide rule, and have begun to realize its possibilities.*

Soot Blowers as Adapted for Use on Economizers

At comparatively low temperature soot forms in greater quantities than at high temperatures. For example, in an economizer in which the temperature is low as compared with boiler temperatures, it does not take long for quite a thickness of soot to accumulate. The automatic scrapers provided to remove this soot have not given entire satisfaction. These scrapers are made to embrace two tubes, and to avoid binding they are not set up close to the metal. Consequently there is always a certain thickness of soot that is never touched by the scraper, and investigation has proved in a number of cases that the scraper soon glazes the soot into an enamel-like scale that can be removed only by tapping which requires time and labor.

To obviate this difficulty, which necessarily lowers the efficiency of the economizer, mechanical soot blowers have recently been adapted for use on economizers. The accompanying illustration shows a Diamond mechanical soot-blowing equipment as installed by the Diamond Power Specialty Co., of Detroit, on a number of economizers in one of the largest plants in the country. This particular case is different from the standard installation on boilers as the blowers are operated from above instead of from below. This change was made necessary on account of lack of space. The units are set on 9-ft. centers, each having an effective radius of 4½ ft. The operating wheels are attached to a beam overhead within reach of the platform. From the same point the steam valve may be opened. Usually the chain hangs downward and may be operated from the floor or an operating platform.



DIAMOND MECHANICAL SOOT BLOWERS INSTALLED ON ECONOMIZERS

The blower unit is inserted in the economizer, as indicated in the view at the left. It is equipped with venturi-type expansion jets, which economize on steam and are set to blow between the various rows of tubes. There are no stops, so that the blower unit can make a complete revolution and in this way cover the entire lengths of the tubes. One unit removes the soot from half the surface of the tubes within its radius, while the units on either side remove the balance of the soot. The nozzles project from a single extra heavy pipe, as temperatures are not high enough to warrant the dry-jacketed double-pipe units employed for boiler use and they are not injured by the heat.

The soot and ashes accumulate in a hopper below the tubes and may be drawn out by gravity or possibly by means of a vacuum induced by a steam jet farther down in the discharge pipe. With the steam jet the soot may be blown into the ashpit under the boiler.

*For pointing off decimals see "Power," March 24, 1914, page 400; April 21, 1914, page 551.

Following is a report from the engineer in charge of the plant in which the foregoing installation was made:

	Temp. Ahead of Economizer, Deg. F.	Temp. After Economizer, Deg. F.	Temperature Difference, Deg. F.
With scrapers.....	437	383	54
With blowers.....	437	320	117

The figures show that by the use of the blower the temperature of the gases was reduced 63 deg. lower than when the scrapers were employed. It is evident, then, that the heat transfer was considerably improved and the economy of the economizer increased by several per cent.

Kokomo Underfeed Stoker

A steam-operated underfeed stoker with rocking grates and clinker grinders is made by the Kokomo Foundry & Machine Co., of Kokomo, Ind. The accompanying illustrations (Fig. 1 showing a view of the furnace front and Fig. 2 a view of the stoker assembled) will give some idea of its construction. Fig. 3 is a view of an installation at the plant of the Factory Power Co., Cincinnati,

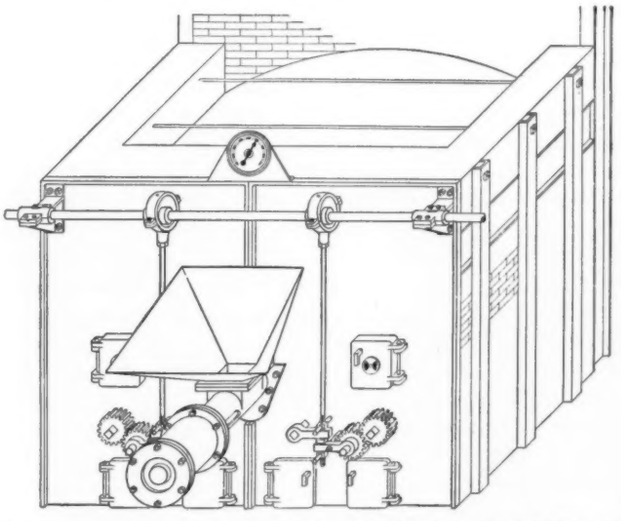


FIG. 1. FURNACE FRONT, SHOWING RAM AND MEANS OF OPERATING GRATES AND CLINKER GRINDERS

Ohio. A steam-driven ram pushes the coal into a retort located centrally in the furnace. Under the influence of a blast supplied by a fan the coal is ignited in this retort and the volatile, in passing up through an incandescent bed, is burned. As fresh coal is constantly pushed into the retort at the bottom, the coke or incandescent coal overflows onto rocking grates at either side. These are constantly agitated so that the fuel is spread evenly and gradually passes down the incline to the stationary grates and thence to the clinker grinders, through which the ashes and clinker pass to the ashpit.

At each stroke the ram pushes into the furnace about 15 lb. of coal. The number of strokes can be varied from none to six per minute, depending upon the demand for fuel. The movement of the ram is controlled by an operating valve driven by the engine running the forced-draft fan. The shaking grates and the clinker grinders are also operated by the same engine through eccentrics on the stoker shaft, as shown in Fig. 1. It is apparent, then, that the amount of coal fed to the furnace and the air to burn this coal are controlled by the speed of the fan engine, while the speed of the engine is controlled by a regulating valve, according to the steam pressure carried in the boiler. Provision is also made for hand adjustment of the operating valve, so that the feed of the coal may be regulated independently of the speed of the fan engine. This is convenient in making adjustments for different kinds of coal and in starting up or shutting

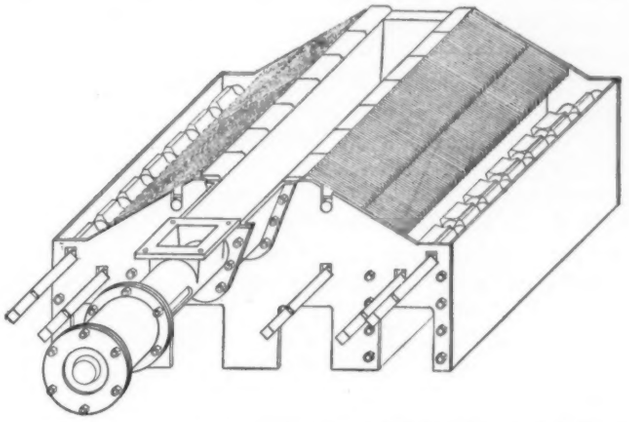


FIG. 2. STOKER, SHOWING CENTRAL RETORT AND INCLINED SHAKING AND STATIONARY GRATES

down the boiler. A damper is also provided in the air conduit for hand control of the volume of air to the furnace.

The following claims for this stoker are made by the builders: Effective grate area, 70 per cent. of firebox area; bituminous coal which may be burned per square foot of

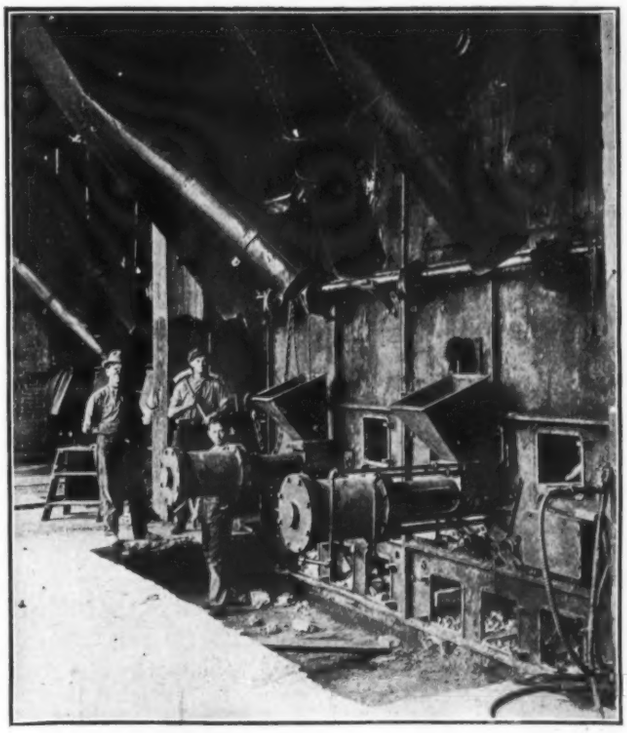


FIG. 3. KOKOMO STOKERS INSTALLED AT THE PLANT OF THE FACTORY POWER CO., CINCINNATI, OHIO

grate area, 60 lb.; blast required, less than 1 in. of water; draft required, less than 0.3 in. of water; power required to operate the ram and fan engine, 2½ per cent. of boiler power; rated boiler horsepower for one coal pusher, 350; overload capacity, 150 per cent. of rating; guaranteed efficiency of stoker with a clean boiler, 70 per cent.

Study of Draft in Boilers

By C. F. Hirshfeld*

SYNOPSIS—A simple explanation of how draft may vary in different parts of a boiler.

In a previous article the subject of chimney draft was developed by analogy to certain hydraulic phenomena and was illustrated graphically. The hydraulic analogy can be carried still further and used to explain certain phenomena which have become rather prominent since "differential" or multiplying forms of draft gages have become common and have been used to analyze the variations of draft through the boiler settings, flues and stacks.

If water be assumed to be flowing in a pipe of uniform section but bent into the shape shown in Fig. 1, the velocity at all points must be the same, but the pressure against the walls of the pipe will vary from section to

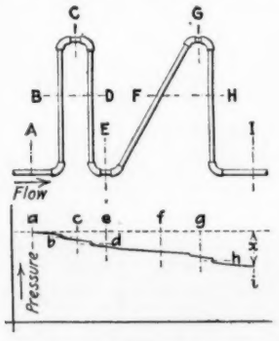


FIG. 1. PRESSURE DROP IN HORIZONTAL PIPING

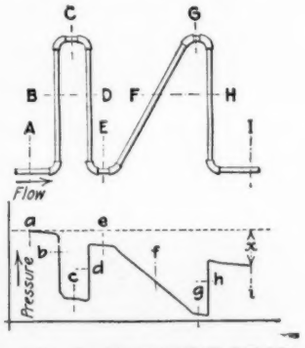


FIG. 2. PRESSURE DROP IN VERTICAL PIPING

section. In the first place, there must be a loss of head because of friction. Therefore, if Fig. 1 be assumed to be a plan view and if the pipe be assumed to be in a horizontal plane, there must be a drop of pressure from section to section all along the length of the pipe, due to the friction loss. This is shown graphically in the lower part of the sketch. It should be stated that if the velocity were high in the case assumed, there would be local variations of pressure at the bends because of the centrifugal effect, but such variations may be neglected for the line of development here chosen.

If, now, the pipe be imagined as located in a vertical plane, conditions are different and the variation of pressure will be shown as in Fig. 2. The static pressure at the tops of the loops must be less than that at the bottoms by the equivalent of the pressure due to a column of water equal in height to the loop. Thus, starting with *A*, the pressure falls slowly, owing to frictional loss in the straight piece of horizontal pipe. Then it falls more rapidly, because of frictional loss in the first elbow, and still more rapidly as the water rises in the pipe *BC*, the pressure decreasing here both because of friction and of elevation. The loss of pressure in the bend *C* is divided into two parts; in the first part the friction and change of elevation both cause a loss; in the second part friction causes a loss and change of elevation causes a gain of pressure. The course of the rest of the graph should be readily understood without further explanation. It should, however, be noted that if points *A* and *I* are at the same elevation, the difference of the static pressures at the two points is only that due to the friction loss in the pipe connecting them, irrespective of where its convolutions may lead it in elevation. If the point *G* happened to be under consideration on the other hand, this statement would be far from true.

These ideas may now be applied to the gases flowing through boilers and may be used to demonstrate the correctness of certain experimental findings that are often questioned because of their apparent absurdity. There are few boilers in which the gases are not required to travel up and down in their passage through the setting. In some the vertical distances are great, in others, small. For the sake of averages a single-ended Stirling boiler will be chosen for discussion.

A section of such a boiler is given in the upper part of Fig. 3, and a graph of absolute pressures of the gases passing through the boiler is given in the lower part of the same figure. A draft, or slight "under-pressure," is assumed just above the fire at the point *A*. If the temperature of the gases passing through the boiler remained constant and equal to that immediately over the fire, the variations of pressure would be shown by the full-line graph. From *A* to *B* there must be a fall of pressure because of both friction loss and decreases of vertical depth, or head of fluid (gas and air in this case). From *B* to *C* there are losses which combine and then losses which partly balance or cancel one another, as discussed in connection with the bends of Fig. 2. From *C* to *D* there must be a loss of pressure due to friction, but a gain or increase of pressure due to increasing depth. Whether the net result will be a gain or loss depends upon the relative magnitude of the two values, and it is worthy of note that while the increase of pressure due to increasing depth remains constant, the loss due to friction must increase in some way with the load. The course of the remainder of the graph in Fig. 3 should be easily understood from the preceding.

It is necessary to consider the effect of the changing temperature of the gases, but before doing so it will be best to consider another hydraulic analogy.

In Fig. 4 is shown a venturi meter, now commonly used for the measurement of water. Pressure gages are shown attached to the meter in three places—at the entrance, at the throat and at the exit. At the entrance, the section of the pipe is large, velocity is low and the pressure against the walls of the pipe is high. At the throat, the section is small, the velocity is high and the pressure is correspondingly low because what may be called pressure, or static energy, has been converted into velocity, or kinetic energy. At the exit, the section is again large, the velocity low and the pressure correspondingly high. With a frictionless tube and with idealized flow, the pressure at the exit end would be the same as that at the entrance if the sections and elevations at the two points were the same. Because of the friction and eddy losses which exist with real materials, the exit

*Chief of Research Department of the Edison Illuminating Co., Detroit, Mich.

pressure will always be lower than the entrance pressure if the sections are the same. The pressure changes in the case of a real tube are shown graphically in the figure.

If, now, it be assumed that the temperature of the water can be greatly changed while it is flowing through the tube, pressure conditions may be greatly altered. Assume, for instance, that the temperature can be increased or decreased between the entrance and throat. It is obvious that this brings in energy changes and volume changes that did not exist before, and the expressions for the pressure changes become much more complex and resemble those used in dealing with flow of steam or gas through a nozzle more than they do those familiar to the student of hydraulics.

Returning now to the boiler illustrated in Fig. 3, it is desired to determine, if possible, the effect of the changing temperature of the gases. It is obvious that the temperature must change rapidly between points *A* and *B*. Experiment shows the drop of temperature from

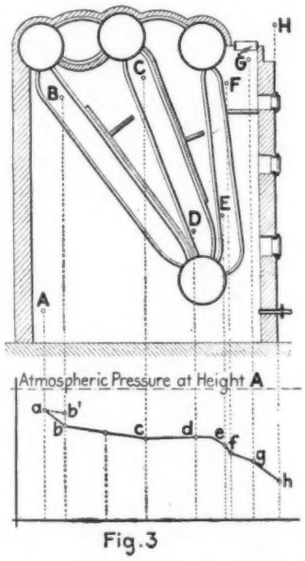


Fig. 3

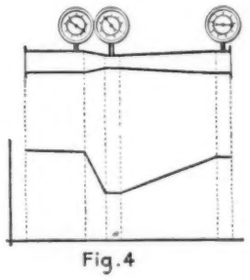


Fig. 4

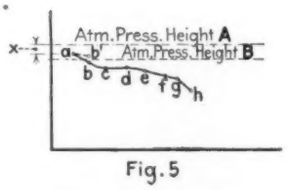


Fig. 5

FIGS. 3 TO 5. ANALYSIS OF BOILER DRAFT

Fig. 3.—Drop in draft through Stirling Boiler. Fig. 4.—Pressures in Venturi Meter. Fig. 5.—Graph of Fig. 3 reduced to underpressure

A to *B* to be of the order of 1000 to 1500 deg. F. Such a drop of temperature would certainly cause a great diminution of gas volume and, if the cross-section of the passage did not change proportionately, would produce a corresponding decrease of velocity. This would bring about a smaller drop of pressure because of friction losses if no other pressure changes occurred.

But it must be remembered that the decreasing temperature, without any proportional change of pressure, will give the gas increasingly greater density as it rises, so that the weight of each successive layer that goes to make up the column of gas *AB* tends to be heavier than the one below it. The result of this will undoubtedly be a less rapid drop of pressure than shown by the full line *ab* of the graph in Fig. 3. Further, if the successive sections of the gas passage do not decrease proportionately to the decreasing gas volume, they will, so far as the gas is concerned, represent increasing cross-sections. This would give the same effect as the discharge tube of a venturi meter, that is, an increasing pressure.

It is obvious that if all of these effects happened to occur together, the net result would be a less rapid decrease of pressure between *A* and *B* than originally shown in Fig. 3; it might, for instance, resemble *ab'* in that figure. If the effect of the changing section happened, on the other hand, to be opposite to that described, the line of pressure change would lie between *ab* and *ab'*.

The same lines of reasoning applied to other parts of the path of the gases will give similar results. It is interesting to note that, even without such modifications, the gases flowing from *C* to *D* may actually flow from a region of lower to one of higher pressure. The modification brought in by temperature change may make this effect still more noticeable, because the temperature decreases and the density tends to increase proportionately as the gas flows down this pass. If the proportions happen to be chosen in certain relationships, this may result in giving a much higher pressure at the point *D* than indicated on the graph in Fig. 3.

It is not, therefore, impossible to find the gases in a boiler flowing from a region of lower to one of higher pressure despite the fact that on first inspection this does not seem possible. As a matter of fact, it is a common phenomenon in engineering and can be studied easily in the case of the venturi tube. There the fluid flowing through the throat has a low pressure and yet flows out of the discharge end of the tube against a much higher pressure.

Thus far the discussion has been in terms of absolute pressure, but before closing it will be well to translate it into terms of draft or pressure below atmosphere (under-pressure), as this is the more common, though the less intelligible method of expression. For this purpose the graph of Fig. 3 is reproduced in Fig. 5. Two dot-dash lines are drawn horizontally across the figure, one representing the pressure of the external atmosphere at the height of the point *A* and the other representing the lower pressure of the external atmosphere at the height of the point *B*. Draft at the point *A* is measured as the difference of pressure *x*, while draft at the point *B* is measured as the difference of pressure *y*. It is obvious that, if the proportions shown in the figure are approximately correct, it must be perfectly possible to get a lower draft at the top of the combustion chamber than is maintained immediately over the fire. This can actually be done and is, moreover, the common method of operation. In other words, the space above the fire acts almost exactly like a chimney filled with hot gases.

It is also obvious that if the whole graph in Fig. 5 were shifted vertically upward, as could be done by further closure of the damper, the point *b* might be raised above the line representing atmospheric pressure at the height of *B* and yet the point *a* might not reach the line representing atmospheric pressure at the point *A*. This would mean that under such conditions there would be a positive, or over, pressure at the top of the combustion chamber or first pass when there was still a draft, or under pressure, at the bottom of that chamber. This is also a common occurrence in boiler practice and may lead to troublesome results.

Expansion Joints should be located in approximately straight pipe lines at such intervals that the extreme change in the length of pipe will not exceed the safe travel or range of the expansion element and that the force or strain exerted in moving the length of pipe may not be excessive and start leakage.

An Electrically Driven Water-Works Plant

By E. M. Ivens

SYNOPSIS—By replacing the steam-driven equipment, which was operating under disadvantageous conditions, with electrically driven pumps and compressors and rearranging the system, a saving of over $6000 per year to the municipality was effected.

Prior to Jan. 1, 1915, the municipally owned and operated water-works plant at Greenville, Miss., was steam-operated, as were the sewage-disposal pumps. The equipment consisted, in brief, of a 900-cu.ft., cross-compound steam, single-stage air compressor for lifting the water from three deep wells into surface storage reservoirs; one 3,000,000-gal. triple-expansion, direct-acting steam pump for furnishing the water to the main; and one 2000-gal. per min. vertical-shaft centrifugal sewage pump located in a pit and operated by a tandem-compound automatic engine with a quarter-twist rope drive. There were also two 300-cu.ft. straight-line air compressors and two 750-gal. per min. simple direct-acting steam pumps reserved for emergencies. Steam was furnished by one 300-hp. internally fired boiler and one 250-hp. water-tube boiler.

An average of two million gallons of water and one million gallons of sewage was pumped per twenty-four hours; the former against approximately 65 lb. pressure and the latter 45 lb., the pressure varying somewhat with the stage of the water in the river into which the sewage was pumped. No tower and tank or elevated storage of any kind was provided, and this compelled continuous operation of the water pump under widely varying conditions of load.

The fuel and labor costs amounted to nearly $20,000 annually, and as this seemed excessive, it was decided by the city council to devise ways and means for an improvement. A proposition was received from the Delta Light & Traction Co., which owns the local lighting franchise, offering to pump all water and sewage electrically, to bear the cost of the necessary machinery and its installation and to maintain the operating force, for approximately $14,000 per year. The price also included fuel and labor for banking the fires under the boilers as required by the State Board of Fire Underwriters. The proposition was promptly accepted and the contract signed.

In the purchase of the electrically operated machinery by the Delta Light & Traction Co., price was obviously of secondary importance, economy of operation being the first consideration. After investigating various methods of pumping from deep wells and into mains and exercising the utmost care in the selection of types and sizes of apparatus, it was decided to install air lifts in the wells and utilize single-stage centrifugal pumps for supplying the mains. The equipment purchased consists of two 549-cu.ft. duplex-type air compressors operated through short belt drives by two 50-hp. motors; two 1500-gal. per min., single-stage centrifugal pumps, each direct-connected to a 75-hp. motor; one 750-gal. per min. single-stage centrifugal pump direct-connected to a 50-hp. motor; one 2000-gal. per min. vertical-shaft centrifugal sewage pump direct-connected to a 75-hp. motor; one 900-gal. per min. horizontal-type centrifugal sewage pump direct-connected to a 35-hp. motor; and the necessary switchboard for control. All the motors are of the 2300-volt, three-phase, 60-cycle type.

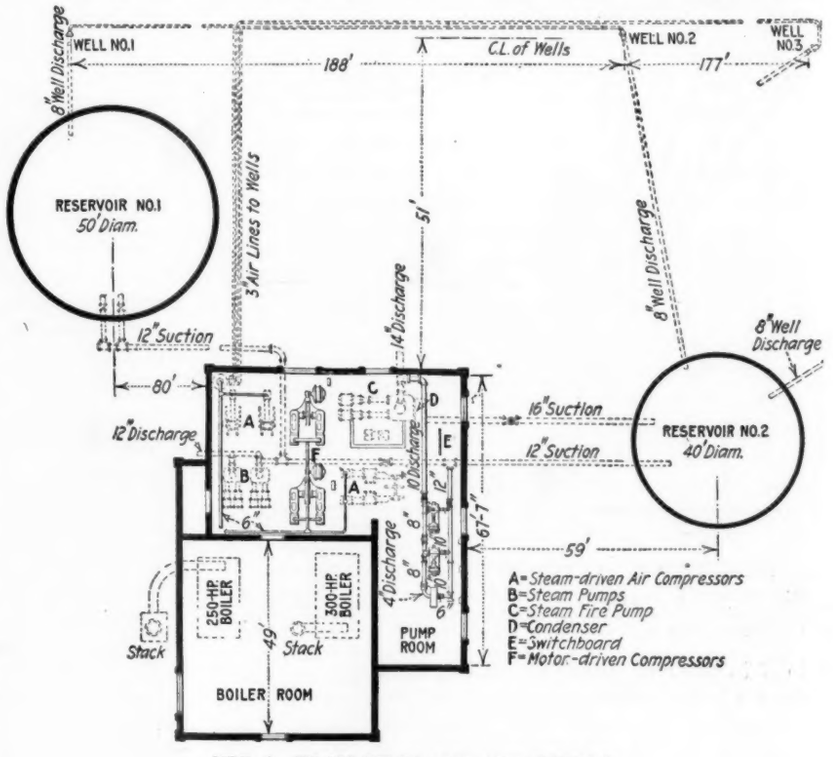


FIG. 1. PLAN OF PLANT AND WELLS

Fig. 1 is a floor plan of the plant and shows the location of all machinery, reservoirs, wells and piping. The dotted outlines indicate the old steam-driven equipment and the full lines the new electrically driven machinery. Since the drawing was made, a fourth well has been drilled near reservoir No. 2, and connected to the receiver manifold in the same manner and with the same-sized piping as are the other three wells.

Equipment Supplying Compressed Air

The compressors have inclosed crank cases, and all wearing surfaces except the inside of the air cylinders are lubricated by the "splash" system. Forced-feed lubricators serve the air pistons, cylinder walls and valves.

The air-discharge openings from each pair of air cylinders are connected, and valves are so located, that any compressor in the building (either steam- or electric-driven) may be made to furnish air to any one or to all the wells.

Air-inlet pipes are brought to the outside of the building and the ends screened, thus insuring the drawing in of the coolest and cleanest air available.

Water Pumps and Sewage Pumps

The three centrifugal water pumps and the discharge piping are shown in Fig. 2. The suction and discharge piping is such that water may be drawn from either reservoir and either one or all of the pumps may be operated on the line. A by-pass from the suction to the discharge is provided between the two larger pumps so that the discharge from one may be connected to the suction of the other, giving, in effect, one two-stage unit having the water capacity of one pump and the combined pressure capacity of both pumps. The object of this arrangement is to make available sufficient water pressure in the mains for ordinary fire-fighting purposes and thus obviate the necessity of starting the steam apparatus. In case of large conflagrations, one or all of the steam pumps may be added, and banked fires are maintained under the boilers in readiness for just such emergencies.

A flow meter is installed in the discharge header and

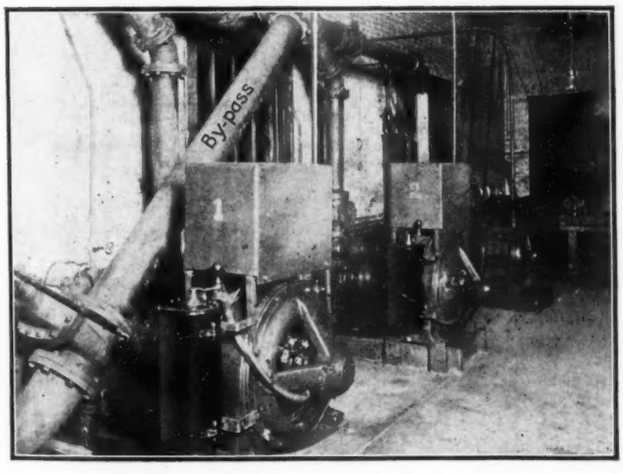


FIG. 2. PUMPS AND DISCHARGE PIPING

an integrating wattmeter is mounted on the switchboard, so that power input and water horsepower output may be readily calculated at any time and any falling off in efficiency, in this way, can be quickly noted and the cause remedied if possible.

The horizontal pump is operated as long as the fluid level remains within the suction limit in the pit, and when the inflow does not greatly exceed the capacity of the pump. Conditions other than these require the operation of the other pump, which, as before stated, is of larger capacity and of the vertical-shaft submerged type. The smaller unit is operated during the greater part of the time.

The Wells and Their Piping

The wells, with their surface piping, are shown in Fig. 1. The discharge opening of the receiver is connected to a manifold having valves conveniently placed so that any one or more of the wells may be pumped as occasion demands. The well conditions are as follows:

	No. 1	No. 2	No. 3	No. 4
Total depth, ft	500	500	500	500
Diameter of casings, in	8	8	8	10
Static head, ft	31	31	31	31
Pumping head, ft	68	56	61	66
Capacity, gal. per min	400	500	600	1200
Operating air pressure, lb	42	42	42	42
Length of air line, ft	161	149	154	159
Submergence, per cent	58	67	60	59

It will be noted that the operating pressure of all the wells is identical, and since the same is true of the starting pressure, it is possible to start and operate any group of wells without throttling the air to any one. This is a point often overlooked by engineers in designing an air-lift system for a number of wells.

The proper depth of submergence was ascertained by experimenting with varying lengths of air lines. After

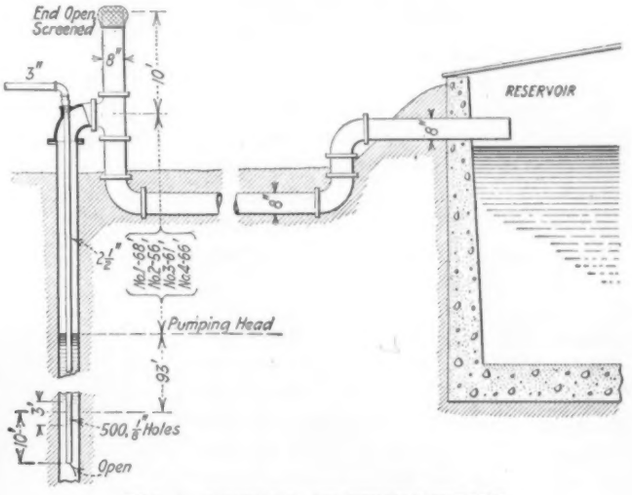


FIG. 3. METHOD OF PIPING WELLS

determining the most advantageous point of submergence, the wells were balanced by slight changes in air line length so as to operate on uniform pressures.

In Fig. 3 is shown the method of piping the wells. The air and water are separated at the well-top. The air is vented off through the riser pipe and the water flows by gravity to the reservoir. The object of this is to reduce the velocity of flow and reduce in proportion the frictional losses. Another advantage is the elimination of losses incurred by the air "riding" over the water, which occurs when an attempt is made to convey the mixture horizontally in a closed piping system.

The lower end of the air line is open, and for 10 ft. from the end a number of ⅛-in. holes are drilled. The sum of the areas of these holes is greater than the cross-sectional area of the pipe, and since the holes are nearer the surface, practically all of the air travels through them, thoroughly aërating the water. The end is left open so as to dispose of scale or other obstructions and prevent their accumulation and eventual clogging of the small holes.

Fig. 4 is a view of the discharge from the 10-in. well through an opening in the top of the reservoir. The flow is exceptionally steady and free from the characteristic pulsations of the air-lift.

The operating engineer is required to make and record hourly readings of the electrical instruments and water meter and submit a daily report on the operation of the plant. From the data contained in a typical report of

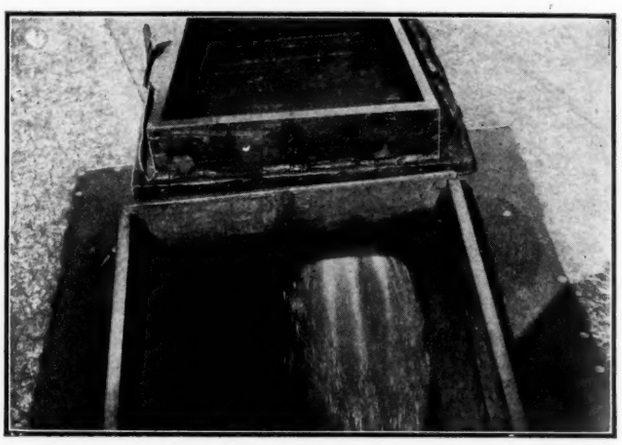


FIG. 4. DISCHARGE FROM 10-IN. WELL

this kind, the following results have been calculated and conclusions reached.

Fig. 5 is a chart plotted from a typical daily report. The "horsepower" (input) curve includes the energy necessary to operate all water-pump and air-compressor motors and the dotted addition to this curve represents the energy expended to replenish the storage in the reservoirs. Likewise, the "water horsepower" (output) represents the total energy realized by lifting the water from the wells with compressed air and forcing it into the mains with the centrifugal pumps. The dotted addition to this curve represents the energy for replenishing the storage. The efficiency curve is the ratio of output to input and is therefore inclusive of all mechanical, electrical and air-transmission losses. The line loss between the electric generating station and the water-works plant is not included, but this is not justly chargeable to the machinery.

In analyzing these curves, it should be remembered that they are not obtained from test results wherein the load conditions have been adjusted to conform to the economical rating of the apparatus; and further, owing to the absence of a suitable elevated storage tank, one of the centrifugal pumps at least is called upon to operate continuously and very often under decidedly disadvantageous conditions of load. Tests of the two larger pumps made under full load show an increase in overall efficiency of 4 per cent. over the best shown on the curve. Similar tests with the small pump show an increase of 2.5 per cent.

The steam apparatus which was replaced operated under the same disadvantages, but greater proportionate losses occurred because of lack of care in the selection of the size of pump to meet the duty. A 2100-gal. per min. triple-expansion pump was called upon to operate under never more than two-thirds load and often less than one-third of its rated load, except, of course, in case of large fires.

Besides this, the air-transmission losses were enormous and the wells were improperly piped. A 900-cu.ft. compressor operating at full capacity against from 60 to 70 lb. pressure barely furnished the required amount of water from the wells. By enlarging the surface piping and repiping the wells, the free air necessary was reduced to approximately 500 cu.ft. per min. and the pressure was reduced to 42 lb. The saving resulting from these changes could have been realized formerly had proper care been exercised.

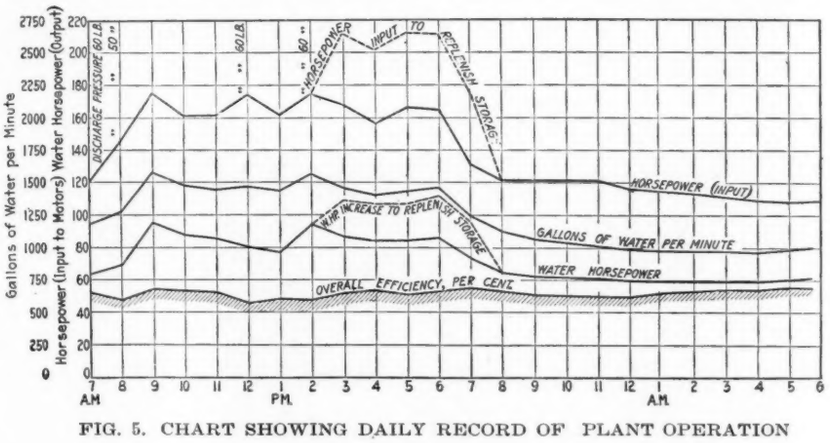


FIG. 5. CHART SHOWING DAILY RECORD OF PLANT OPERATION

PRINCIPAL EQUIPMENT OF GREENVILLE WATER-WORKS PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Pumps	Horizontal Single-stage, centrifugal	6-in.-1500 gal. per min.	Main supply	1750 r.p.m., direct-connected	A. S. Cameron Steam Pump Co. Wks.
1	Pump	Horizontal single-stage, centrifugal	5-in.—750 gal. per min.	Main supply	1750 r.p.m., direct-connected	A. S. Cameron Steam Pump Co. Wks.
2	Air Compressors	Duplex single-stage	11x12-in. air cycles	Air-lifts	Short belt drive, 210 r.p.m.	Ingersoll-Rand Co.
1	Pump	Vertical single-stage, centrifugal	10-in., 2100 gal. per min.	Sewerage	1750 r.p.m., direct-control	DeLaval Steam Turbine Co.
1	Pump	Horizontal, single-stage, centrifugal	8-in., 900 gal. per min.	Sewerage	1750 r.p.m., direct-control	DeLaval Steam Turbine Co.
2	Motors	Horizontal induction	75-h.p.	Driving 6-in. pumps	1750 r.p.m., 2300 volts, 3-phase, 60 cyc.	General Electric Co.
1	Motor	Horizontal induction	50-h.p.	Driving 5-in. pumps	1750 r.p.m., 2300 volts, 3-phase, 60 cyc.	General Electric Co.
2	Motors	Horizontal induction	50-h.p.	Driving air compressors	1150 r.p.m., 2300 volts, 3-phase, 60 cyc.	General Electric Co.
1	Motor	Vertical induction	75-h.p.	Driving sewage pump	1750 r.p.m., 2300 volts, 3-phase, 60-cyc.	General Electric Co.
1	Motor	Vertical induction	35-h.p.	Driving 8-in. sewage pump	1750 r.p.m., 2300 volts, 3-phase, 60 cyc.	General Electric Co.

Some Historic Dates Concerning Coal—The first mention of the occurrence of coal in the United States, according to the Geological Survey, is made in the journal of Father Hennepin, a French Jesuit missionary, who in 1679 recorded the site of a "cole mine" on the Illinois River, near the present City of Ottawa, Ill. The first actual mining of coal was in the Richmond Basin, Va., about 70 years after Father Hennepin's discovery in Illinois, but the first records of production from the Virginia mines were for the year 1822 when, according to one authority, 54,000 tons were mined. Ohio probably ranks second in priority of production, as coal was discovered there in 1755, but the records of production date back only to 1838. The mining of anthracite in Pennsylvania began about 1790, and it is said that 55 tons were shipped to Columbia, Penn., in 1807. Reports of the anthracite trade are usually begun with the year 1820, when 365 long tons were shipped to Philadelphia from the Lehigh region. Prior to this, however, in 1814, a shipment of 22 tons was made from Carbondale, also to Philadelphia. It is probable that the actual production prior to 1820 was between 2500 and 3000 tons.—"Coal Age."

Editorials

Conserving the Older Men

Conservation of efficiency should be quite as important as the development of efficiency, yet this seems often to be overlooked and its disregard is nowhere more common than in the labor of the power house or the factory. Able-bodied and capable men of mature years are continually being dropped to make room for younger and more energetic men. Granted that younger men can stand the wear and tear better than their elders, are they as well qualified by experience to work as efficiently? Competency is often to be more greatly desired and valued than energy and is usually dependent upon experience which can only be gained by time.

No plant or shop which is efficiently operated allows its equipment to deteriorate and become obsolete without endeavoring to prolong its useful life. Ways and means are evolved to lengthen the life of a boiler, an engine, a lathe or any piece of machinery, but when the workman commences to show signs of slowing up—when his capacity for work begins to lessen—his days are numbered and he is soon dropped. The younger men have not had his experience, probably are not as competent and are much more apt to be less careful in their work, yet they are taken on, for they will learn by experience, but perhaps only to be in turn thrown out when they commence to show the strain. When they begin to tire under a full day's labor, they are believed to be losing efficiency.

It is quite possible, however, that what is really needed is a well-planned treatment of "scientific management" to enable men to maintain their efficiency and value. Systematic and complete rests at regular intervals frequently work marvels. Scientific management has done great things in increasing (developing) efficiency, and it can be employed to bring about equally important results in conserving efficiency. Certain European railway shops have realized the wisdom of prolonging the useful life of their skilled mechanics and have provided rest rooms with comfortable couches. The men who show signs of failing efficiency during the day, who have formerly been efficient, are allowed a specified rest period each day at the expense of the shop. These periods must be devoted to resting and the men are taught to relax and recline on the couches so as to allow their tired bodies to recuperate most rapidly—there is a science of lying down in this progressive age. Standing around and loafing are not countenanced, and it has been found that the daily rest period divided into a number of short fixed intervals results more beneficially than if the rest is taken all at one time or during longer and less frequent intervals. All men do not require the same amount of rest, it is true, nor do all require as frequent or as long resting spells; some men recuperate more rapidly than others. Each man should be a special subject for an individual investigation of his resting requirements, but if this is not accurately and carefully undertaken, the regular rests nearly invariably prove beneficial to the men in reviving their efficiency.

These scientifically arranged rests are intended only for elderly mechanics, and the purpose has been not to increase the efficiency of the men so much as to maintain their efficiency. So gratifying have been the results that in many instances the output of elderly men which had shown a marked falling off before the introduction of the "rest cure" has appreciably picked up and in some cases equaled or exceeded the output they had previously been capable of and even bettered the record of much younger men who could work efficiently throughout the day without signs of fatigue. Whether the same treatment of young men well able to stand a full day's work would not also lead to increased efficiency has not yet been established. In some cases it doubtless would. It is simply an application of "scientific management."

⁂

Designing Substations for Convenient Operation

If the designers of industrial substations had to operate the "creations" of their drafting boards, many features that now inconvenience the engineer and his subordinates would surely be eliminated. It is of course impossible to standardize substation design outside a very limited range, and it would be a waste of time to try to specify an ideal layout for general application. It is much more to the point to emphasize departures from the best practice observed in the close study of specific installations.

A small volume might be written about the perils and costs of insufficient space. Why is it, after all the publicity this most important factor in safe operation has received, that we still find high-voltage disconnecting switches mounted in shallow concrete compartments without covers, the blades bare to chance contact in case of a misstep and the exposed studs no higher than a cat's back from the foot passage behind the switchboard? The man responsible for such a layout will claim that it is perfectly safe; that no one ever goes behind the board except the electrical assistant on shift, and that this experienced and cautious individual knows that he takes his life in his hands every time he goes behind the padlocked screen; and that "outsiders are never allowed." Well, if the designer only had to live in one of these installations himself, he would think differently. He would insist on putting in enough disconnecting switches so that by no possibility could an oil switch undergoing repairs or adjustment become alive through the backing around of energy from the low-tension busbars through a set of supposedly dead transformers. If there is any single method of insurance so effective as placing disconnecting switches on both sides of all high-tension oil switches, let the designer produce it. The additional cost should not be a consideration, so important is it to guard against shocks from behind the operator's back, so to speak. It is a singular fact that the low-tension equipment of a substation will often be given several

times the space assigned to the more dangerous apparatus, with the idea, apparently, that by segregating the latter in a sort of electrical contagious ward, crowding the lightning arresters close under the roof and massing bus compartments and switch cells into one small part of the premises, safety will descend on the place.

Putting switchboards into substations in such a manner that the operator cannot command the entire outfit from one place is a questionable procedure. The practice of placing one set of panels behind another set, so that the operator is obliged to go behind one board in order to handle another, is its own condemnation, and only less open to criticism is a switchboard installed on such an angle that its panels are in two planes. Locating a high-tension board at right angles to a low-tension group of panels so that the instruments of one are partially concealed when the operator stands before the other is one more point in design which should be avoided whenever possible.

These are only a few of the things that the man who runs a plant knows might have been arranged differently had the man behind the drawing pen been more familiar with the actual operating details. Often, perhaps generally, there is no connection between these two men, but if plant designers can be brought into closer contact with operating problems, the whole industry of power engineering will be the gainer. Whenever and wherever the operating engineer or the electrician has a chance to suggest points about plant arrangement to the man whose word governs the design, let him make the most of his opportunities; and wherever the designer is near enough to the field, let him also seize the chance to learn all that he possibly can about the way the structures which he produces work out in daily practice.

Pennsylvania License Law Declared Unconstitutional

A "citizen and taxpayer" filed a bill in equity against the city of Philadelphia for the purpose of testing the constitutionality of the act of Apr. 18, 1889, P. L. 49, which provides for the examination and licensing of engineers having charge of steam boilers, steam engines, and appliances connected therewith, in cities of the first class. The lower court upheld the constitutionality of the act, and the plaintiff appealed to the Supreme Court on the ground that the act was unconstitutional in that it was local and special and an attempt to regulate labor or the pursuit of a trade in violation of the provision of Article 3, Section 7, of the Constitution.

The Supreme Court upheld the contention, declared the bill to be unconstitutional, and Pennsylvania is again without a license law.

With the first ruling of the court no fault can be found. It says: "That the statute was intended to be local in its effect is apparent upon its face, as it applies only to the operation of steam boilers and steam engines within certain rather narrow territorial limits; that is, within the boundaries of cities of the first class." If a boiler is unsafe without a licensed engineer in Philadelphia, it is just as unsafe in Meadville. And while boilers in outlying isolated portions of the country, where their explosion would be comparatively innocuous, might be exempted in the same way that dynamite might be allowed in large quantities in an isolated mining operation, while it would not be tolerated on Broadway, any attempt to confine a law to cities of the first class is evidently putting restrictions on engineers and employers in those cities to which engineers and employers in the same class, located in cities of smaller size, are not subject.

The opinion of the court, that the act in question is also to be regarded as special in that it applies to particular persons only of a class, appears to us to be less justifiable. The opinion says: "It does not, however, apply to all engineers or persons having charge of or operating steam boilers or steam engines in cities of the first class; but it expressly excludes persons having charge of or operating steam boilers or steam engines under ten horsepower, locomotive boilers used in transportation, and steam engines and steam boilers carrying less than fifteen pounds per square inch. It is not apparent why an engineer operating an engine and boiler over ten horsepower should be licensed, while one without a license may operate an engine and boiler of less than ten horsepower, or carrying less than fifteen pounds pressure per square inch.; nor does any good reason appear why a stationary engineer must have a license, while a locomotive engineer is not required to have one."

The reason for the exemption of the locomotive engineer is that, from the very nature of the case, a high-class man, a man of experience and training, is required upon a locomotive. His principal concern is with the driving of the locomotive as a motor vehicle, although he has a general oversight of it as a traveling steam plant. An experienced fireman goes with him—and none but an experienced fireman would go very far—and the locomotive and the engineer and fireman are inspected and examined by and must be satisfactory to the Interstate Commerce Commission. There is little need of a law to prevent a railroad from putting a hobo in charge of a locomotive, and the boiler is under inspection by others than the men who run it.

The exemption of the ten-horsepower boiler at less than fifteen pounds pressure is of the same order as that indulgence which allows a family to carry a can of kerosene among its household supplies, but places restrictions on its carrying a barrel or more of gasoline.

The explosion of a two hundred-and-fifty-horsepower boiler at one hundred and fifty pounds pressure would set free over three hundred times as much energy as the explosion of a ten-horsepower boiler at fifteen pounds pressure.

It is to be hoped that Pennsylvania will try again with a state-wide law, and that the Supreme Court will not declare it unconstitutional because it does not require a licensed engineer to run a kitchen stove.

That eight more states have this year been added to those having workmen's compensation laws, making a total of thirty-two, indicates that the state seems to awaken to a realization of the social importance of the worker.

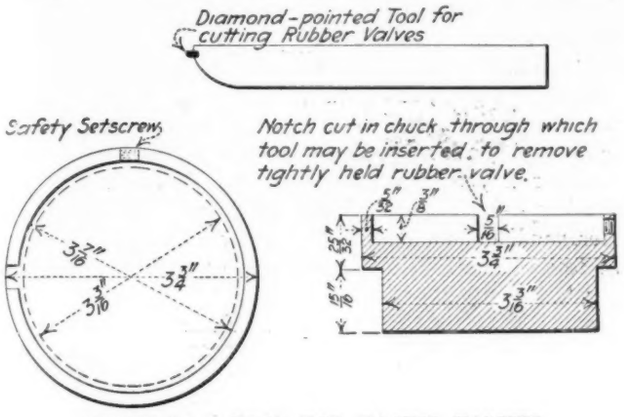
Palm Beach suits in Pittsburgh! Can you imagine them? But they are worn in greater number every week; the Pittsburgh *Post* says so. Seems as though the smoky city is about to lose its reputation—and get a better one.

Mr. Employer take a trip down into your engine room one of these hot days and see if the conditions could not be made more tolerable.

Correspondence

Facing Up Rubber Pump Valves

The illustration shows the tool and chuck we use to face up worn rubber pump valves. The chuck for holding the valve is made of brass and has a shoulder so that it can be held in a lathe chuck. The tool for facing is of soft steel, 5/8x5/8x8 in., in the end of which


Diamond-pointed Tool for cutting Rubber Valves
Safety Setscrew
Notch cut in chuck through which tool may be inserted to remove tightly held rubber valve.

CHUCK AND TOOL FOR FACING VALVES

is set a very small diamond which does the cutting. A diamond will make a smooth finish on soft rubber when run at high speed.

We have a number of brass holders for valves of different sizes. This method has been used for years, during which time we have faced hundreds of valves, using the same diamond, and it will last for years yet. Many of our pumps have 32 valves costing 35c. each; this means a saving of about $11 by facing the worn valves.

THOMAS PASCOE.

Norway, Mich.

Machining a Piston Ring

In reply to Samuel L. Robinson in the issue of July 6, page 24, I desire to say that my method of machining piston rings described on page 353, Mar. 15, is neither novel, nor expensive, and it has been used over twenty years. The expansion disk and filing fixture may be made of hardwood and used in repair work; its product is hard to beat. The aim is to obtain a true-fitting ring.

If a ring be machined for a certain diameter and inserted into a cylinder or inspection gage of that diameter and both held in good light, no light should show between them, neither should joints (diagonal) lap over. If light shows between the ring and gage (or cylinder) it is sprung or distorted, therefore defective. Any machining process that produces the first type is correct.

Piston rings and also the grooves in the piston should have their sides machined to a glossy finish. Unfaced rings as left by the cutting-off tool show a poor bearing if rubbed upon a true surface plate. It pays to make the glossy finish rather than to wear it, for when the rough surface has worn away the ring will rattle in its groove.

The real cause for scoring or cutting is "dirty" (poor mixture) iron of which the parts are made or dirty unfiltered oil.

My statement that a tight piston scores and cuts itself, for there is nothing to yield or give, but that the piston ring is flexible and floats in its groove and will yield at its points, is based on experience during which 4000 gas engines were fitted with rings with no allowance for circular expansion. The pistons in those engines were fitted by the "bump" method. They had to be taken out and high spots eased until they passed inspection. No trouble whatever was experienced with ring expansion. This I believe explodes the piston-ring circular expansion theory.

For a description of the "bump" method of piston fitting the reader is referred to *Power*, page 606, Apr. 18, 1911, to an article on "Fitting Trunk Pistons for Gas Engines," by Olaf Olafsen, paragraphs 5, 6 and 7. This method shows up bad rings and pistons.

Piston rings of steam engines and air compressors follow the same rule. They should be rough-turned and seasoned two weeks or longer before being finally finished.

G. STROM.

Titusville, Penn.

Ground Interfered with Parallel Operation

In a plant ordinarily operating several 1500-kw. direct-current generators in parallel with two substations, there were running one Sunday morning two of the machines—one driven by a gas engine and the other by a vertical cross-compound steam engine. Everything was going along as usual, when suddenly there was a loud report, the

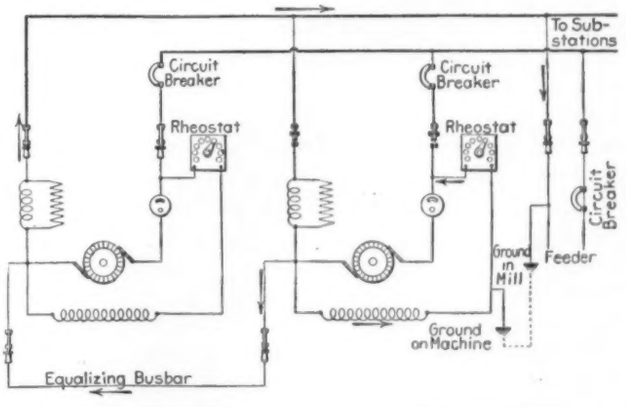


DIAGRAM SHOWING PATH OF CURRENT

brushes and commutator throwing fire and the breaker opening on the steam-engine unit. As the load was getting light it was not necessary to put the machine back on the busbars, as the gas engine and the substations could handle the load. But before shutting down the steam engine we tried the voltage and found it to build up all right, and the engine was under complete control by the governor. The trouble was then blamed on the

gas engine's surging, and motorizing the steam-engine unit.

In the evening it became necessary to put the machines on the line, as the load was coming on. When it came to putting on the steam-engine unit, the switchboard operator built up the voltage and stood ready to put it on the bus. He signaled the engineer to throw in the equalizer switch near the generator, and when this was done the voltage dropped from 265 to 40. On pulling out the equalizer switch the voltage came back again. This was repeated every time the switch was thrown and indicated that the real cause of the trouble was not with the gas engine, but with the generator itself. A test with a magneto soon revealed the trouble.

A ground had developed between the field rheostat and the shunt field. Anyone connected with an industrial plant knows how difficult it is to keep the system clear of grounds, and moreover the ground is always shifting from one side of the line to the other. This time it happened to be on the side to cause trouble; that is, on the same side as the equalizer switch. When the latter was closed it grounded the opposite end of the field, and the ground that developed on the machine caused a bypass, or shunt, around the shunt field and made the voltage drop. Reference to the sketch will make this plain.

The trouble was located under a metal clamp that held the shunt field wires against the frame of the machine leading to the terminal board. All metal clamps were then discarded. I would advise anyone having similar conditions to examine these points for trouble.

JAMES E. KILROY.

Lincoln Place, Penn.

Aneroid Barometers in Power Houses

A knowledge of atmospheric pressure is necessary to every engineer, for on this knowledge rests the operating efficiency of the turbines and the power plant in general.

The mercurial barometer is generally used, but the average results obtained by the observer are never above criticism. If we imagine a barometer in a perfectly vertical position reading 30 in., with its cistern properly adjusted and at a temperature of 78 deg. F. in a building 5000 ft. high in New York City, the correct reading would be:

Barometer	30.00	in.
Temperature 78 deg. F.	0.134	in.
	29.866	in.
Correction to standard gravity	0.008	in.
	29.858	in.
Correction for altitude	0.001	in.
Influence of gravity	29.857	in.

If standard readings are required it is necessary that these corrections be taken into consideration. To say they are not necessary is ridiculous, for they are necessary if standard readings are wanted, and the reason for using a mercurial standard barometer is to obtain accurate results.

Aneroid barometers on the whole have rightly earned a bad name, and in many instances dealers in this country have bought the cheapest foreign instruments and sold them at ridiculous prices. There are good ones made, and while the mercurial barometer will be the standard instrument, there are many places in which readings of atmospheric pressure are taken where the aneroid would be more useful and more constantly accurate, provided it was properly and accurately constructed and compensated for temperature.

When compensated no correction for temperature is necessary, there is no gravity correction and no cistern to adjust, and the dial is more easily read than the scale of a mercury barometer.

If made with noncorrosive parts, such as german silver or phosphor bronze, moisture will have no bad effect on them, whereas mercury, even when exposed to the air, will oxidize rapidly. When in this state it needs cleansing or else it will stick to the tube in minute shreds, causing the readings to be highly inaccurate. Mercury barometers need cleaning at least once a year, to remain accurate.

Since barometers of the aneroid type are portable and safe to transport, can readily be checked at any weather bureau for their reading (about once a year is all that is necessary), have no bothersome corrections to apply, take up less room, cost less, more nearly match the other instruments on the gage board and are more easily read than mercury barometers, I fail to see why their use should not become more general, especially when reliable instruments can be procured.

P. RICHARD JAMESON.

Rochester, N. Y.

Mechanical Stokers on Shipboard

Referring to the editorial comment on my communication in the July 27 issue, it is stated in the first sentence that you believe that the success of the mechanical stoker for stationary service is complete. It is possible to use mechanical stokers in stationary, marine and locomotive services. They have proved successful in stationary practice. We know that they are successful in locomotive service. Please state more definitely what service is meant by "everywhere."

Referring to the second paragraph of your comment, it does not seem proper to question the success or probable success of mechanical stokers on board ship because of the inability of the naval architect to provide means for coal handling on shipboard in the same efficient manner as engineers provide for such work in stationary practice. Further, the probable success of the mechanical stoker on board ship could not be judged by the qualifications of a peculiar type of boiler setting.

When the art of burning coal was not developed in stationary practice as it is today, it was believed impossible to provide for as high boiler settings as we have now. The stoker manufacturers have fought hard for the increase in height of settings which has resulted in such success. It is a matter of evolution on board ships just the same as in stationary practice, and by the fulfillment of such evolution and recommendations of the work done in stationary service, naval architects can obtain the same results as have been produced by the engineering profession on land.

W. J. KENNEY, Chief Engineer,
Underfeed Stoker Co. of America.

Chicago, Ill.

[Everywhere: Wherever coal is burned for generating steam.—Editor.]

An Old-Time Engine and a Modern Plant

While inspecting some of the properties of the Pacific Gas & Electric Co. last month, I came across an old-time steam engine at Sutter Creek, Calif. The name plate shows that it was built by the Vulcan Iron Works, of

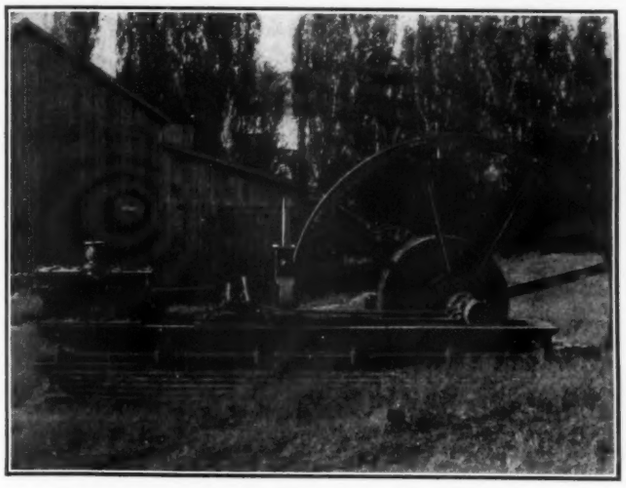


FIG. 1. A 50-YEAR-OLD VULCAN ENGINE

San Francisco, in 1865. The engine has about a 12-in. bore, 36-in. stroke of piston, Meyer riding cutoff and a 10-ft. flywheel, and is shown in Fig. 1.

I was informed by old residents that the engine was used to drive the Eureka Mill and that it has been shut

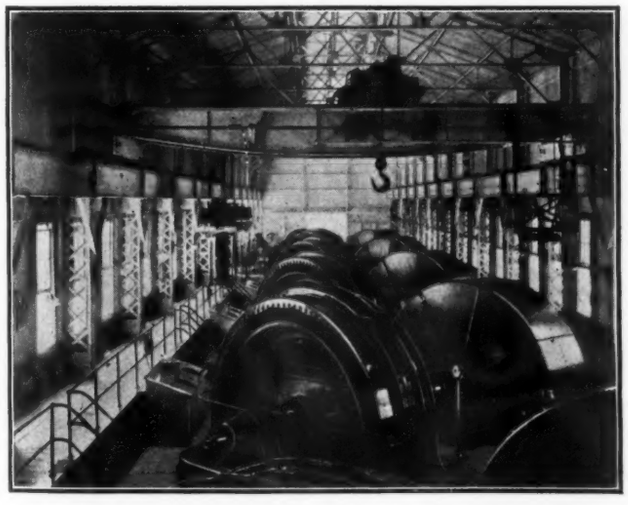


FIG. 2. THE ELECTRA POWER HOUSE OF THE PACIFIC GAS & ELECTRIC CO.

down for nearly thirty years. No doubt, it was considered quite large at the time of its installation and the most uptodate prime mover of fifty years ago.

About twenty miles away, at our Electra power plant, there are five 5000-kw. generators, to be seen in Fig. 2, which shows the advancement made in prime movers in this locality in fifty years.

V. R. HUGHES.

San Francisco, Calif.

[Pictures of old engines are interesting. If any other readers have any real old ones we will be pleased to print them.—Editor.]

Emergency Cylinder-Head Repair Aboard Ship

Referring to Mr. Dobson's letter on page 691, May 18, showing the method used to turn his fan-engine cylinder cover into a relief valve, it must have required a great deal of care in screwing down the cover, otherwise there would be danger of stripping out the white metal.

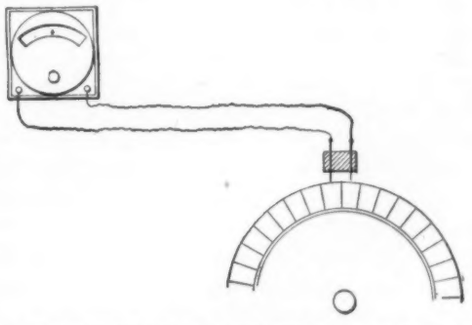
A much better job could have been done in port if the cylinder cover and cylinder had been made a ground joint, and new studs a couple of inches longer fitted so that a strong spring could be put under each. Then the cover would become a proper relief valve that would not require new nuts every time it acted.

E. R. PEARCE.

Rochdale, England.

Locating the Neutral

Brushes on motors or generators are so placed on the commutator that they make contact with commutator bars connected to coils lying in the neutral space between the polepieces. It sometimes happens that during installation the brushes become shifted, and if there are no marks on the brush rigging to show the correct position, or the windings are covered, tracing the connections to coils lying in the neutral space is difficult. In a case like this it is common practice to rock the brushes back and forth until a position is found where no sparking is apparent, clamp the brush rocker in this position and take it for granted that they are in a neutral position. Possibly



A SIMPLE WAY TO LOCATE THE NEUTRAL

because of the good arc-suppressing qualities of the brushes no sparking is noticed, although the circulating currents in the armature due to the brushes' being off neutral are sufficient to cause heating which will soon destroy the insulation and cause a breakdown. A simple way to accurately determine the neutral position for the brushes is shown in the accompanying sketch.

A suitable block of insulating material, preferably fiber, is drilled to permit inserting two pieces of about $\frac{1}{16}$-in. brass or copper wire. Two ends are then connected to a low-reading differential voltmeter, although one with zero at one end of the scale will do if the other type is not available. The other two ends are sharpened and spread a distance equal to the width of the commutator bar. The machine to be tested is run at a constant speed while the points are moved around the circumference of the commutator. The voltmeter will deflect in one direction, the voltage decreasing as the neutral point is approached, and rising again in the opposite direction as the points

are moved beyond it. The position at which the meter indicates zero is noted, and the brushes are set accordingly.

P. JUSTUS.

Cleveland, Ohio.

Auxiliary Oiler for Hot Bearing

A generator bearing slightly out of true required more lubrication than could be provided in the ordinary manner of oiling, so the chief engineer devised a clever auxiliary automatic oiler out of a discarded "student" lamp. Removing the burner from the lamp, which had a central standard with a reservoir on one side and a burner on the other, the two connected by a tube, giving a gravity flow of oil to the burner, he fastened the standard to the cover casting over the bearing, drilled a hole through the casting, inserted a round wick through this hole just over the hungry bearing, fixed the other end of the wick in the tube of the lamp. Gravity and capillary action fed the oil through the wick, dripping it onto the bearing. A stop-cock or valve in the oil tube below the lamp reservoir controls the flow of oil. There has been no excessive heating of the bearing since.

HERMAN B. WALKER.

Washington, D. C.

Incompetence and Carelessness

In line with your editorial in the issue of July 20, "Incompetence and Carelessness," my scheme to promote safety may be of interest, especially since none of my men have ever been injured seriously enough to be absent from duty, which may be attributed entirely to this system.

I take a new man over all that part of the plant in which he is to work and endeavor to point out the dangers he will encounter and how to avoid them. I ask him about his former job and what the customs were there and try to start him in on the kind of work he has been accustomed to doing until he has become used to his new surroundings. He must promise to take no risks and to at once report any dangerous situation he sees.

I watch each man at his work and study the hazards peculiar to his job and discuss them with him. At a meeting of all the men, held every two weeks, we have a talk over the things observed since the last meeting. Published accounts of accidents are discussed and how to avoid similar occurrences in our plant. If any man has been careless or has made a mistake that would be likely to injure him or others, he is asked to tell all about it, not in an accusing or humiliating way, but impersonally, and then plan to avoid its recurrence. He is never reprimanded at these meetings, because to "bawl a man out" before his fellows only humiliates him and makes him feel antagonistic, and he looks forward to safety meetings with dread instead of pleasure.

You must have coöperation to be able to say, month after month, "No accidents this month." When a man suggests any means of reducing the hazard of any operation, utilize it until something better is suggested, even if it helps only a little. The cost is generally low, and it is a step in the right direction. Besides, the man who made the initial suggestion may, if properly encouraged, find a way to eliminate the danger entirely. You have to get "folksy" with the men when you talk "safety," otherwise they will be indifferent and you waste your time and theirs. A compliment and handshake help wonderfully.

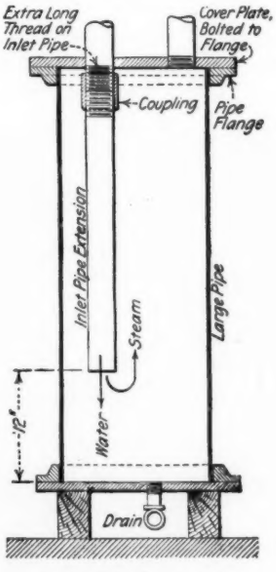
A permanent warning sign set up inside of an enclosure is good to caution strangers, but a sign hung on a throttle, switch or valve is no good and no protection. I had three dozen signs made and gave one to each man with his name painted on it. They put them up properly enough, but usually forgot to take them down and for that reason they fell into contempt, so I got padlocks with chains attached, one for each man stamped with his name. When a man goes to work on an apparatus, he puts his lock on the source of power, no matter if there are ten other locks belonging to other men already on, because they may finish their jobs and remove their locks, then the operator may start the machine, but there is no way for him to start while any of the locks are still on. There are only two keys to each lock, one in the possession of the employee and the other locked up in the office.

SAM H. FARNSWORTH.

So. Chicago, Ill.

Home-Made Steam Separator

The device illustrated has been successfully used as a separator on a number of engine tests. The smaller inside pipe leads the wet steam downward at a good velocity, while the upward flow to the outlet is comparatively slow. The sudden change in the direction of the steam



SEPARATOR MADE FROM PIPING

flow throws the water out at the bottom of the separator, where it is carried off by the drain.

It may not be possible to rig up such an apparatus for large-diameter pipe lines, but for anything up to a 5-in. steam line, using a 14- or an 18-in. outside pipe for the separator barrel, the "makings" may usually be found at the plant. Asbestos lagging around the separator not only gives greater dryness, but also makes considerable difference in the comfort of those who are using the apparatus.

By the use of flanges to make the top pipe connections the inlet extension may be set over near to one side making this design suitable for larger pipe than that mentioned.

Easton, Penn. R. S. BAYARD.

Inquiries of General Interest

Height of Water Column on Return Tubular Boiler—What is the proper height for a water column on a return tubular boiler?

E. J. M.

The water column should be set at such a level that the lowest visible portion of the gage glass will be not less than 2 in. above the level of the highest part of any fire-tube.

Causes Which Reduce Efficiency of Boiler Heating Surfaces—What are the leading causes which would reduce the efficiency of the heating surfaces of a boiler?

D. M.

The principal causes would be imperfect circulation of the boiler water, excessive velocity of furnace gases over the heating surfaces, low temperatures of the furnace gases; soot, ashes or dirt on the outside, and scale, mud or dirt on the inside of the heating surfaces.

Determining Thickness of Boiler Shell—Should not the thickness of a boiler shell be determined by drilling?

A. T.

The thickness of plates can usually be determined by measurement with the aid of straight-edges at joints and with calipers at ordinary openings, but where this cannot be done, drilling holes in the plates may have to be resorted to. In obtaining the thickness by drilling, the drilled holes should be large enough for admission of a hook gage or caliper long enough to span over the burr made by the drill.

Sizes of Steam and Exhaust Pipes—What size would be suitable for the steam and the exhaust pipe of a 14x36-in. noncondensing Corliss engine, running 100 r.p.m., supplied with steam at 100 lb. gage pressure and developing about 135 i.hp.?

W. B. J.

Assuming the engine requires 26 lb. of steam per indicated hp. hour, or about 3500 lb. of steam per hour, then for ordinary conditions of plant arrangement the minimum sizes of piping should be 4 in. for steam and 5 in. for exhaust pipe.

Heating Surface for Closed Feed-Water Heaters—What is the rule for the amount of brass-pipe heating surface required for closed exhaust-steam feed-water heaters?

M. H. O.

Allowing 30 lb. of feed water per horsepower per hour, it is usual to supply ¼ of a square foot of heating surface per horsepower, which should be sufficient to heat the feed water from 60 deg. F. to about 194 deg. F. When the heater is supplied with ½ sq.ft. of brass-pipe heating surface per horsepower of 30 lb. of water per hour the water will be heated to about 204 deg. F.

Heating Surface Based on Surface Exposed to the Air—In estimating the heating surface of pipes, coils, and radiators used in steam heating, are the inside or outside sizes to be considered?

F. W. C.

Designation of the size of pipe is understood to apply to the measurement of its inside diameter, and the radiating surface, which it is usual to express in square feet, is the surface which is exposed to the air. The heating surfaces of ordinary pipes, coils, and radiators are understood to refer to actual measurements of their exterior surfaces which are exposed to the air to be heated.

Blowoff Pressure of Safety Valve—The area of a safety valve is 10 sq.in.; the weight of the valve and valve stem is 10 lb.; the distance from the fulcrum to the point of bearing of the lever on the valve steam is 4 in.; the weight of the lever is 15 lb. and its center of gravity is 20 in. from the fulcrum. If the ball is 35 in. from the fulcrum and weighs 75 lb., at what pressure will the valve blow off?

H. C.

The weight of the valve and stem would balance a force of 10 lb.; the weight of the lever would balance $(15 \times 20) \div 4$, or 75 lb.; and the weight of the ball would balance $(35 \times 75) \div 4 = 656.25$ lb.; or all acting together would balance a total pressure of $10 + 75 + 656.25 = 741.25$ lb. As the area of the valve is 10 sq.in., then the valve would blow off for a pressure of $741.25 \div 10 = 74.125$ lb. per sq.in.

Effect of Opening Field Circuit of Alternator—What would result from opening the field circuit of an alternating-current generator when carrying full load in parallel with the other generators of the same system, provided the other machines were running sufficiently under capacity to pick up the load?

F. D. A.

The machine having the open field circuit would probably draw an abnormally heavy current at a very low power factor. The induced field from the armature current would tend to make it run as a motor, but the torque would not be great. It is probable that the current would be large enough to blow the circuit-breaker.

Advantage of Butt-and-Double-Strap Boiler Joint—For the longitudinal joint of a cylindrical boiler shell, what is the advantage of a butt-and-double-strap joint over a lap-seam joint?

W. M. S.

When a lap joint is under stress, the sheets forming the shell endeavor to assume a true cylindrical form which causes a bending action of the material along the joint, and such bending has frequently been a cause of rupture. With a butt-and-double-strap joint, all of the material can be made up into true cylindrical form, so that with a properly formed shell there need be no deformation of the sheets from a pressure within the boiler and consequently little or no danger from rupture by bending. An additional advantage of the butt-and-double-strap joint is that, with the same thickness of shell plate, the joint can be made to resist a higher pressure than a lap joint.

Depth to Which Solid Iron Cube Would Sink in Water—Would a solid cube of cast iron sink in water to a depth of 20 miles?

A. E. B.

When a body is submerged in a liquid, it is buoyed up by a force equal to the weight of as much of the liquid as the body displaces, and therefore, when otherwise unsupported, it will sink to a depth where the density of the body and of the liquid are the same. At a depth of 20 miles, the pressure of the water would be about 45,830 lb. per sq.in., and for that pressure the water would be compressed to a density of about 1.15 times that of its density at the surface when under atmospheric pressure. Under atmospheric pressure, the density of cast iron is about 7.21 times that of water, and when compressed on all sides by an equally distributed pressure, its density would increase at least as rapidly as that of the water. The cube of cast iron would therefore sink to a depth of 20 miles and, unsupported excepting by the water, would continue to sink to a greater depth, until a depth was reached where the density of the water was equal to that of the iron.

Flooding Superheater—What is meant by flooding a superheater and how is it performed?

C. H. B.

In the ordinary operation of superheaters, excessive temperature of the heating surfaces is prevented by the flow of saturated steam to the superheater, but when there is little or no flow of steam through the superheater, as when steam is being raised or when engines are shut down, then in most forms of superheaters provision must be made to prevent the superheating surfaces from attaining an excessively high temperature. This is usually accomplished by admitting water to the superheater by a connection with the water space of the boiler, and the operation is called "flooding the superheater." While thus flooded, the superheating surfaces act like submerged boiler heating surfaces and generate saturated steam. The connections are usually so arranged that any steam formed in the superheater while flooded may be liberated in the steam space of the boiler, and so that, when it is desired to resume operation of the superheater, the flooding water may be drained off by closing the flooding valve and opening a drain cock in the flooding pipe.

[Correspondents sending us inquiries should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Cylinder Friction and Lubrication Testing Apparatus*

By Alan Flowers†

SYNOPSIS—An apparatus is described which is capable of testing cylinder lubricants at various rates of feed under piston-ring pressures from 2 to 9 lb. per sq.in. and at steam temperatures up to 800 deg. F. (426⅔ deg. C.). The cylinder has an 8-in. bore, the stroke is 8 in., and at present the apparatus is being run at speeds up to 300 r.p.m. The results of some tests are plotted, showing the actual readings as taken and the effects of steam pressure, steam temperature and cylinder-wall temperature with and without steam, on the friction coefficient for two different lubricants. The contents of the paper are further summarized in the eleven conclusions at the close of the paper.

The work on this subject was begun at the University of Missouri in 1909 and a small apparatus embodying the principle was constructed and tried out.‡

With the information obtained from the small apparatus, a much larger one was designed and has been assembled at the Ohio State University, where it is now set up and available for tests to determine the characteristics of cylinder friction and for the comparison of different cylinder lubricants under the various conditions of steam temperature, steam pressure, piston-ring pressure, speed and oil feed that obtain in service.

The apparatus consists of a steam cylinder within which two pistons connected by a piston rod are placed. The space between the two pistons has a constant volume, so that steam

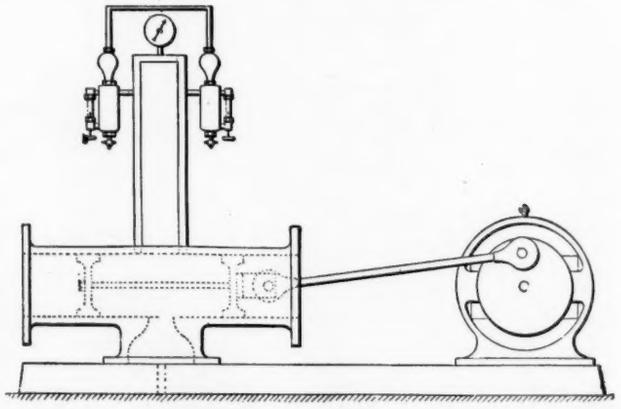


FIG. 1. DIAGRAM ILLUSTRATING PRINCIPLE OF CYLINDER FRICTION APPARATUS

admitted to this space does no work on the pistons. Two steam pipes are brought into the cylinder at points just short of the parts rubbed over by the piston, so that oil carried along by the steam may readily reach the rubbed surfaces.

An electric motor drives the two pistons by means of a crank disk and connecting-rod, and the net input of the motor is a direct measure of the friction of the two pistons and piston rings. Steam is supplied by a gas-burning coiled-steel-tube boiler.

Fig. 1 shows a diagrammatic sketch illustrating the main principle of the apparatus.

The boiler, manufactured by the White Co., is made of ⅜-in. coiled steel tube, capable of working at pressures up to 1000 lb. per sq.in. and at temperatures up to 800 deg. F. (426⅔ deg. C.). Natural gas and compressed air are supplied to the burner, which is capable of giving considerable degrees of superheat.

The cylinder is 8 in. in bore and 36 in. long. A 3-in. drain leads out from the middle of the bottom. The cylinder and first set of piston rings were manufactured by McIntosh, Seymour & Co.

The connecting-rod is 33 in. long and the stroke is 8 in. This makes the maximum angularity of the connecting-rod less than 7 deg., a value so small that its effect is negligible. Hess-Bright ball bearings at each end of the rod make the

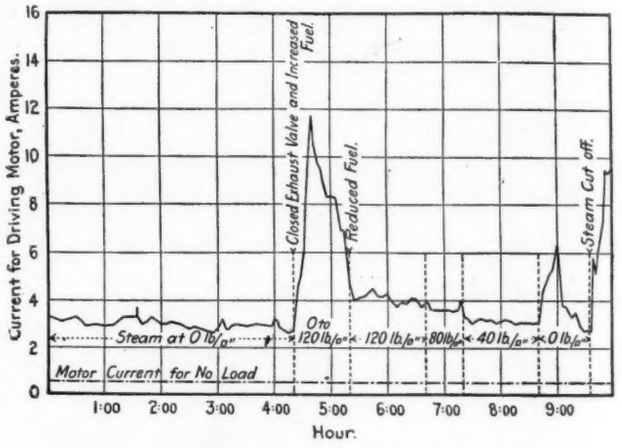


FIG. 2. READINGS AS TAKEN IN A TEST

connecting-rod friction negligible compared to the cylinder friction.

A General Electric 110-volt, 400-1200 r.p.m. motor with two identical armature windings and commutators, each rated at 5.5 amp., drives the pistons. One of these armature windings is used as a motor winding and the other is used to give the generated electromotive force. For any constant value of field excitation, the spare winding also gives an electromotive force which is proportional to the speed. Suitable resistances can be connected in series with a voltmeter so that the speed can be read directly on a suitable scale and so can easily be kept constant. The motor is provided with interpoles and shunt-field speed adjustment, but is being run at present with constant field and variable applied voltage. A motor generator set supplies the power to drive the motor, and rheostats in the separately excited generator field circuit make it a simple matter to control the voltage of the generator, so adjusting or keeping constant the speed of the motor driving the pistons. The motor is fitted with ball bearings and was specially designed for this service, in order to have the lowest possible no-load losses.

Two 1-pint Detroit sight-feed lubricators supply oil in the usual manner to the steam pipes.

Natural gas and compressed air are supplied and are controlled by hand-operated valves, which can be adjusted to give the desired combination of steam pressure and superheat temperature.

A double-plunger pump driven by an adjustable speed motor controls the water supplied to the boiler. The water supply is taken directly from the city water mains at a pressure of approximately 65 lb. per sq.in. A hand-operated valve between the water mains and the pump provides an additional control for the water.

The piston rings at present in use are of the constant-radial-thickness type. Each piston has five slots and one or all five may have rings placed in them. All the rings have a ⅜-in. face and each of the four sets has a different radial thickness, so that the intensity of pressure exerted by the piston rings against the cylinder wall may have values from 2 to 9 lb. per sq.in.

The boiler has a high-pressure steam gage reading to 1200 lb. per sq.in. An Ashcroft standard test gage reading to 300

*Presented at the Eighteenth annual meeting of American Society for Testing Materials held at Atlantic City, N. J., June 22-26, 1915.

†Professor of electrical engineering, Ohio State University, Columbus, Ohio.

‡This apparatus was described in the "University of Missouri Bulletin," Engineering Experiment Station Series, Vol. 2, No. 2, June, 1911.

lb. per sq.in. is connected to the steam line just ahead of the steam cylinder. A valve between the boiler and cylinder can be used to throttle or to cut off the steam. At one time a pressure-reducing valve was also placed between the boiler and cylinder, but owing to the high degree of superheat to which it was subjected, it did not operate satisfactorily and was removed.

A thermometer pocket is placed in the steam line near the boiler, another in the center of the cylinder steam-space and two in the walls of the cylinder, one at each end and opposite the midstroke position of the pistons.

The cylinder-wall pockets were drilled very close to the inner wall of the cylinder, so that the thermometer in them would give the average working temperature of the friction surfaces.

High-grade thermometers guaranteed accurate to one-half a division, manufactured by the Hohmann & Maurer Division of the Taylor Instrument Co., are used to read the temperatures.

PROPOSED MODIFICATIONS

The cylinder ends were provided with flanges, so that the ends could be covered and the exhaust side of the pistons subjected to any desired steam pressure. When the ends are not covered the exhaust side of the pistons is subjected to atmospheric pressure and the corresponding steam temperature by the steam that leaks past the rings. Thus the rubbed surfaces are alternately exposed to the differences of temperature and pressure that obtain in service when running noncondensing. The difference in pressure on the two sides of the piston is an important element in the amount of oil feed necessary, and the difference of temperature an important element in determining the viscocity and therefore the amount of friction encountered by the pistons and piston rings.

In order to further increase the severity of tests with high degrees of superheat, an electric heating coil has been designed, which is to be placed around the cylinder. This will

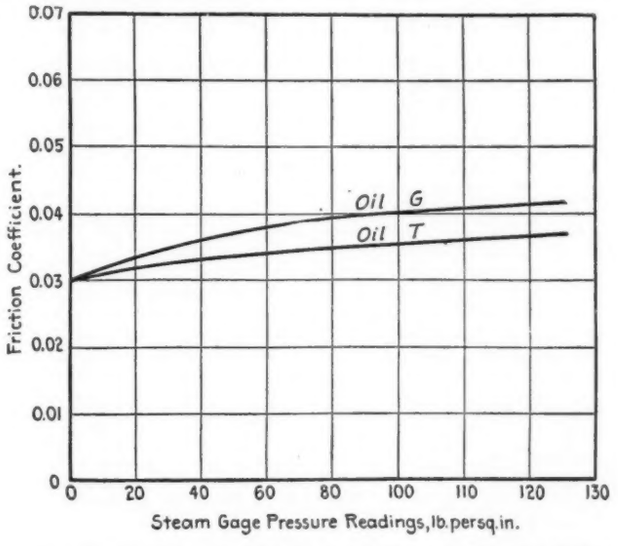


FIG. 3. EFFECT OF STEAM PRESSURE ON FRICTION

produce a heat flow inward and raise the wall temperature, as well as tend to raise the steam temperature.

The sight-feed lubricator gives a rate of flow for any setting of its control valve which is determined by the viscosity of the oil. As the control valve is not near the steam pipes, it is not much above the temperature of the room. At these temperatures the viscosity of cylinder lubricants is very great and changes enormously with small changes of temperature. This makes it almost impossible to get a high rate of oil feed or to keep the rate constant. Moreover, the size of the drop varies with the temperature, the steam pressure and with the rapidity with which the oil is fed, so that the rate of oil feed in drops per minute bears no definite ratio to the pints per hour or any other definite measure.

Oils differ widely in the size of the drops they will form, owing to their variations in surface tension, so that different oils fed at the same number of drops per minute do not necessarily supply the same volume of oil to the rubbing surfaces.

An oil pump working without slip, which will feed any oil at a constant rate that can easily be predetermined or adjusted, is being designed for this service.

A graphical log of a test is plotted in Fig. 2 to show a set of readings as taken and their variations. The value of the current required to drive the motor alone is also plotted as the horizontal line at 0.52 amp. The difference between this no-load current and the total current gives the net current required for the cylinder friction. For this test the friction coefficient could be obtained by multiplying the net current by the factor 0.01366.

An appreciable part of the variations shown here is due to the difficulty of controlling the oil feed. There was an ex-

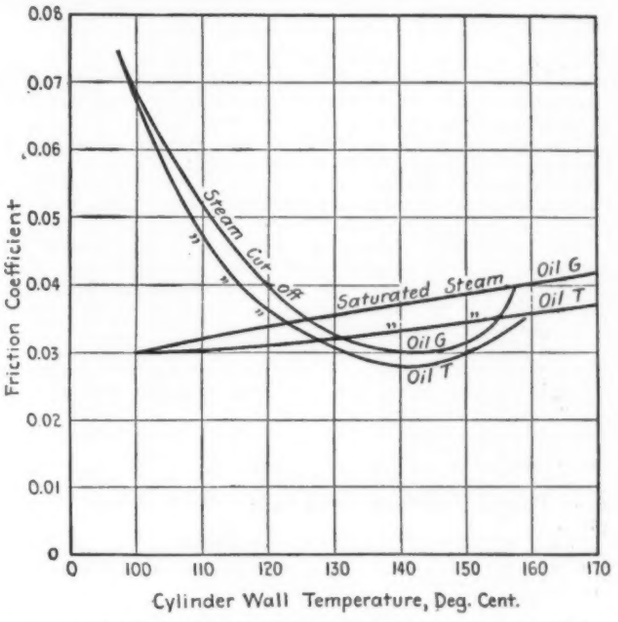


FIG. 4. CYLINDER-WALL TEMPERATURES, AND EFFECT OF COOLING CYLINDERS

cessive rise in friction amounting to 300-400 per cent. when the steam pressure was raised quickly from atmospheric pressure to 120 lb. per sq.in. This excessive friction does not occur when the steam pressure is increased gradually or when it is decreased to a lower value; it may be due to the sudden blowing of the oil out from the space between the piston rings and the cylinder walls.

The effect of steam pressure on the friction is shown in Fig. 3. Saturated steam was used in these tests and results are plotted for two different cylinder lubricants. The friction for low-steam pressure is practically the same for the two lubricants, but at the higher pressures one lubricant gives appreciably more friction than the other.

As the viscosity of oils decreases very greatly with increased temperature, the results given in Fig. 3 are replotted in Fig. 4, but referred to the temperatures measured by the thermometers in the cylinder-wall pockets. Fig. 4 also gives for comparison the friction coefficient for each of the two cylinder lubricants with the steam shut off and the cylinder cooling off. It is noteworthy that these friction curves taken without steam show the increase in friction at lower temperatures that should occur with the correspondingly increased viscosity. It is noteworthy also that the curves show the same relative difference between the two lubricants.

At 97 deg. C. the friction coefficient for both lubricants is the same, and both show a coefficient more than twice as great as that obtained with saturated steam at atmospheric pressure. At the higher temperatures, both show a much lower friction when free from steam than when saturated steam of the corresponding pressure is present.

The larger friction coefficients at the highest recorded temperatures are probably not significant of anything more than the transition from the condition with saturated steam present under pressure to the condition of atmospheric pressure and the absence of steam or water. It is possible, however, that at the higher temperatures the viscosity of the lubricant may be reduced to a point such that it is readily squeezed out from between the rubbing surfaces, and by bringing the surfaces close together, or even into contact, to increase the friction between them.

Other tests showed that when the feed was scanty, the friction was not only large, but subject to sudden large variations.

The effect of shutting off one of the two lubricators was to increase the friction within a few minutes in spite of the fact that some oil was carried to the end at which the lubricator had been shut off. The amount of lubricant carried over in this way to the unlubricated piston was sufficient to keep

the surfaces from sticking or cutting, but not sufficient to give the low friction coefficient corresponding to the total amount of lubricant fed.

Shutting off all the lubricant increases the friction appreciably within five minutes, when steam is present under pressure, but when steam is present at atmospheric pressure it takes at least 30 min. for the friction to change. This difference is doubtless due to the carriage of the lubricant to or away from the rubbing surfaces when steam is present under pressure.

CONCLUSIONS

An apparatus has been constructed which will readily measure the friction coefficient between piston or piston rings and cylinder-wall surfaces.

The conditions of operation of the rubbing surfaces reproduce closely the conditions of service.

Tests may be carried out at various piston-ring pressures, steam pressures, and steam superheat temperatures covering the ranges found in practice.

The modifications described will make it possible to impose conditions more severe than those met with in practice.

Different lubricants do not give necessarily the same friction coefficient and their lubricating value can be determined by means of this apparatus.

Constancy of friction requires a liberal supply of lubricant, particularly when there is a difference of steam pressure on the two sides of the piston. It was observed that a large amount of lubricant is carried directly on out with the exhaust.

Cutting off or reducing the supply of lubricant brings about an increase of friction within 5 min.

Increasing the supply of lubricant may bring about a reduction of friction within 15 min., but at low pressures, or when starting a run with surfaces free from oil, it may take two hours to reach a consistently low value of friction.

An increase in the rate of feed of the lubricant makes a considerable reduction in the friction when the amount fed is small, but with a continued increase of feed of lubricant, the friction tends to approach a certain minimum value.

The friction coefficients obtained so far are all large, 3 to 4 per cent. or more, and very much larger than the values found in well-lubricated bearings.

The friction coefficients obtained and the amount of lubricant necessary are greatly modified by the presence of steam and by the difference of steam pressure on the two sides of the piston.

It is hoped that discussion of the construction and operation of the apparatus may lead to further improvements.

It is a pleasure to acknowledge here assistance in this work from the University of Missouri; Cornell University; the Ohio State University, which has contributed largely for the construction of the apparatus described here; and the Telluride Association, which contributed part of the expenditures for this work. Acknowledgement is also made to M. P. Weinbach, Prof. C. F. Hirshfeld and Dr. P. H. Conradson, for suggestions during the progress of the work.

Cracked and Seized Pistons on Diesel Engines*

By George E. Windeler†

In dealing with the internal-combustion engine as a heat motor, the points of difference between it and the steam engine are considerable. In the steam engine, to obtain the most economical results, everything possible is done to keep the temperatures of the cylinder liner, piston and ports for the incoming steam and all surrounding spaces as near as possible to the temperature of the live steam. To obtain the most efficient results steam jacketing has been resorted to, latterly superheated steam, and the latest innovation has been the adoption of the uniflow engine.

Now, in the internal-combustion engine (in this particular instance the Diesel engine) everything possible is done to keep down the temperature of the cylinder liner, cylinder cover or breech end, exhaust valves and exhaust passages which are in contact with the fuel or gases. In some types the pistons are water- or oil-cooled. Almost as much heat has to be absorbed by the cooling water as is developed in useful work. Therefore special attention has to be paid to water-cooling arrangements to insure that the circulation is thorough and that no air or steam pocketing is likely to occur, and special attention should be paid to the arrangements to prevent short-circuiting in the water circulation, otherwise certain parts are liable to become overheated locally.

In the course of our investigations we found that most of the defects that had arisen on cylinder covers and pistons were due to deposits forming in the water spaces of the cylinder covers and on the cylinder liners. Much time was spent in investigating the cause of such deposits having formed, and ultimately we came to the conclusion that they were not formed on the liners and cylinder walls during the time the engine was working, but after it was shut down. Naturally, the piston, cylinder cover, valves and such parts as are in contact with the combustion space must have a large amount of heat stored in them, and when the engine is shut down this heat is absorbed by the water which remains in the jacket; the quantity of water is comparatively small and a considerable rise in temperature takes place; in fact, sufficiently high in the majority of cases to throw down the salts that were held in solution. We were so sure that this theory was correct that we wrote to users of our engines, suggesting, where the circulating water was known to be of a considerable hardness, that they run water through the water spaces for some time after the engine was shut down—with the most happy results. This information naturally became public, and many Diesel engine users have now adopted this system to advantage.

I have personally inspected a cylinder cover that contained a water space about 6 in. deep and found a deposit as much as 5 in. thick. Naturally, the cover had cracked. The aforesaid suggestion was adopted in this particular station, and the results have been very satisfactory.

In an internal-combustion engine without a water-cooled piston, the heat that has been absorbed by the piston crown must be dispersed down the body of the piston and passed away through the liner to the water space. It is therefore necessary to study carefully the design of the piston head to obtain the best results. At the same time, the piston must be designed in such a way that the load that is applied to the crown shall be transmitted to the crosshead pin without causing any distortion to the piston.

In Fig. 1 is shown a piston with the usual dished top, supported by four radial ribs, two being carried down to the piston-pin boss so as to form a more or less rigid connection between the piston crown and the piston pin, to enable the forces to be transmitted directly with the minimum amount of distortion. It will be noted that this piston is comparatively thin in the crown and in the body, and when fitted to a number of engines it was found to work admirably; but ultimately distortions appeared between the ribs, and it was deemed advisable to modify the design to that shown in Fig. 2, in which six radial ribs are carried well down the body of the piston from the crown, two being carried to the piston-pin boss, with a thicker rib behind the main rib to assist in the transmission of the load. The piston crown was made slightly thicker and, generally, this design has been satisfactory, but at times cracks have developed in the piston top, sometimes the cracks having taken a circular form around the base of the center cone. Such cracks, however, are not of serious import, and pistons which have cracked in this manner have been in use for 12 or 14 months without any trouble, a slight blowing past taking place when starting up, but ceasing after the piston top has become heated, evidently the expansion closing up the crack. But a more serious state of affairs exists when the piston cracks either radially or diametrically, as it is liable to cause seizures in the cylinder owing to the piston losing its rigidity, and consequently its symmetry. It is desirable under such circumstances to immediately shut down and remove the piston.

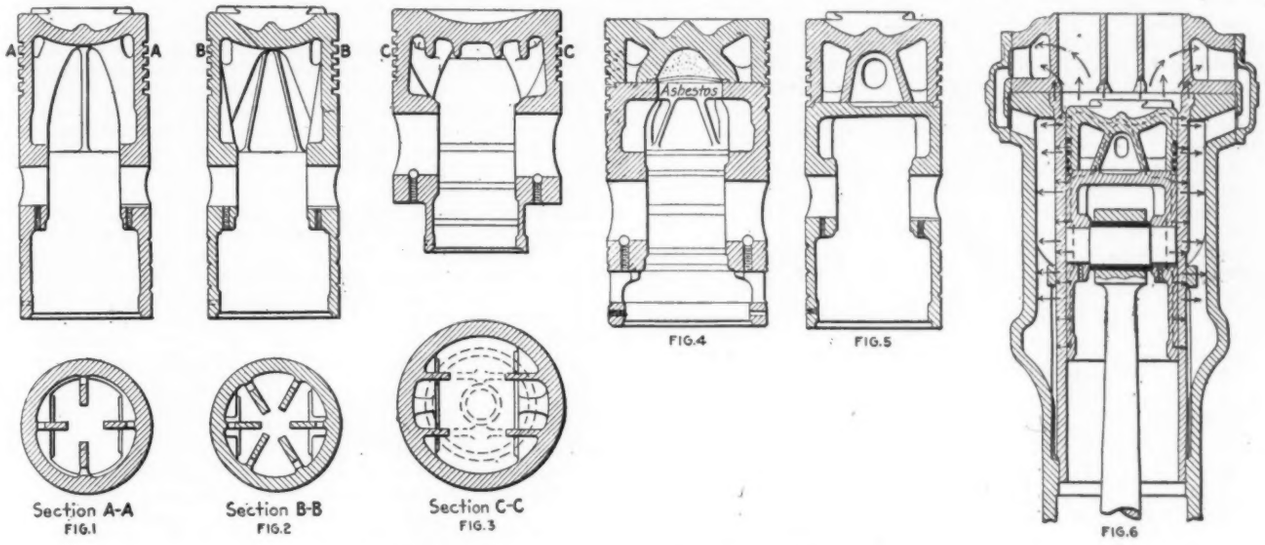
Figs. 1 and 2 refer to pistons 12 in. in diameter; Fig. 3 shows a 20-in. piston, the design of which was similar to the 12-in., but the piston crown was supported by a number of circular ribs projecting into the interior. Radial ribs were also carried down from the crown to the piston-pin boss. This piston at first appeared to be satisfactory, but it was noticed on examining a number of castings which had been unmachined that slight cracks had taken place across the tips of

*Read before the June meeting of the Diesel Engine Users' Association.

†Chief Engineer to Messrs. Mirrelees, Bickerton & Day, Ltd.

these ribs, and on examination it was found these cracks had been set up by the cooling of the casting. A number of such castings were broken up and found to contain many flaws. It was therefore decided to cast the piston in two parts, and Fig. 4 illustrates the type which is now generally adopted by the firm. The construction of the upper part is secured to the main body by six or eight square-necked studs. The object of the square-necked stud, which fits into a square hole in the body of the piston, is to insure that the stud itself will not come out or get slack when the engine is at work.

This piston top is somewhat novel, inasmuch that there are no ribs embodied in the design, the support to the crown being obtained by throwing out a conical cylindrical chamber, which also has the advantage that it forms another lane by which heat can reach the body of the piston for transmission to the water spaces; it also permits of uniform expansion. The upper part of the piston is carefully bedded onto the lower portion, and care has been taken to have sufficient contact area to allow for rapid heat transmission. The internal cone thus formed in the head is filled with asbestos to prevent the heat being thrown down from the crown of the piston onto the connecting-rod bearing. This design has several advantages, one being that different qualities of material may be used for the upper and the lower parts of the piston; the other is that, should any cracks develop, it is a comparatively simple and inexpensive matter to replace the top.



SECTIONS THROUGH VARIOUS PISTON DESIGNS TRIED OUT

The lower part, which acts as a crosshead, must necessarily be of a quality of iron that is hard and that will attain a high polish when running, and not wear readily; the upper part should be of a material capable of resisting heat stresses.

Fig. 5 shows a similar design, as adopted on the 12-in. pistons. When these modifications were carried out a number of experiments and analyses were made by our laboratory with the different qualities of material used, and careful records were taken of such, and when any defects developed we were able to trace the particular quality of material that was used. By this comparative method we were able to arrive at a more or less definite conclusion as regards the quality of material which best suited the purpose. Experiments proved that cast iron containing high percentages of phosphorus was most unreliable, and further investigations proved that the elimination of phosphorus would, to a large extent, remove the difficulty of cracks developing. Great care is taken in controlling the mixtures that are used, and each batch of pistons and cylinder covers, liners, etc., is carefully analyzed and laboratory records taken so as to insure consistency of the material as desired.

Reverting to the seizure of pistons, we have formed the opinion that almost invariably these are due to heating of the piston pin and its bearing, and that such seizures take place almost immediately after starting up. When an engine has been set to work and then shut down, the heat stored in the piston body is thrown down and tends to evaporate the oil in the top end bearing, with the result that when the engine starts up again this particular bearing is not amply supplied with lubricating oil, and seizures take place. Again, running the circulating water through the engine after shutting down tends to minimize this difficulty. As proof of the contention that the heating of this bearing is generally the cause of such seizures, I may mention that the abrasions generally show seizure to have taken place at four points of the circumference of the piston and liner, and if careful note is taken of the position of these abrasions, it will be found that they occur at the point where the piston-pin bosses join onto the thinner section of the body of the piston. At these points there is a comparatively sudden reduction in the section of material, allowing one part of the piston to be extremely rigid and the other more or less flexible. When seizures take place the piston pin becomes overheated, and by reason of its friction fit in the piston body, plus its greater coefficient of expansion, causes an extension to take place, which forces the piston out of shape, flattens the crosshead portion of the piston body, and causes distortion to occur at the four points referred to. If the engine is not shut down quickly, other seizures are liable to occur, but the main seizures will almost invariably be found at these four points. When piston seizures occur, it is desirable that the connecting-rod bolts be carefully examined, as extension of the length of the bolt is likely to take place, and if examination is not made, ultimately fractures of the bolts may occur, with disastrous results.

Fig. 6 shows the general arrangement of the combustion space with the piston in position, to illustrate the transmission of heat to the water spaces.

Properties of an Ideal Steel

The ideal steel contains no break in the continuity of the metal and in adition is homogeneous as regards all constituents affecting its strength or ductility. The lack of continuity may appear as piping, blow-holes or slag inclusions. Slag is not included to any considerable extent in well-made steel, but the piping and blow-holes are necessary evils. One or the other will normally be present in a mass of solidified steel, because the steel when solid occupies a smaller volume than when molten.

The mass of steel solidifies from the outside and its size and shape are approximately determined by this outer solidification. The molten interior continues to shrink while cooling, and unless the deficiency is taken up by bubbles of gas (blow-holes) forming in the interior, there will be a void because of shrinkage. This shrinkage cavity is known as a pipe and is distinguished from the other cavities known as blow-holes.

Blow-holes are bubbles of gas enmeshed in the solidifying metal before they could relieve themselves and rise to the top of the metal. The Bessemer and openhearth processes of refining steel are oxidizing operations, and there is of necessity a considerable amount of oxygen present in the bath of metal, mostly combined with iron. There is also present an appreciable amount of carbon and the combination of the two elements produces gaseous compounds. This reaction takes place in all steels that have not been thoroughly deoxidized, and therefore such steels contain gas bubbles or blow-holes.

The absence of homogeneity is the result of a segregation due to liquidation of the elements other than iron present in the steel, either from design or as impurities. The tendency toward segregation can be minimized in two ways, thermally and chemically, the latter being more effective than the former, but the combination of the two producing the best results.—From a paper by Edward S. Kenney, before the American Iron & Steel Institute.

Heating and Ventilating Modern Hotels*

By Newton L. Schloss†

SYNOPSIS—Some of the difficulties experienced in installing hotel equipment and advantages and disadvantages of various systems.

The heating and ventilating system of the modern hotel is often unjustly criticized. This, in a great measure, is because the promoters and their architects underestimate the cost of the building. As a result the capacity of the equipment is reduced or some of the apparatus is omitted, while the parts of the hotel that appeal only to the eye are completed according to the architect's plan. The designing engineer must sacrifice the efficiency of the heating and ventilating system for rentable area, ceiling height and showy rooms, although if the system fails the entire blame is placed on his shoulders.

An architect should never prepare preliminary plans for a hotel without consulting an engineer with broad experience in hotel heating and ventilating. The contractors should not be asked to submit estimates until heating and ventilating requirements have been carefully studied. After the final plans have been prepared the architect should arrange frequent conferences between manager, steward, chief engineer and consulting engineer and settle all details of size and general arrangement.

While the details of the central heating plant must be determined by financial conditions, it is good practice to have spare boilers, pumps and heater units. Water-tube boilers are desirable, although frequently the allowance for this part of the equipment will not warrant the expenditure.

If an electric plant is installed there is usually exhaust enough for either low-pressure steam or forced hot-water heating. Before its discharge into the heating system the exhaust should pass through a grease extractor, and the condensation through feed water filters before being fed into the boilers. Unless these precautions are taken the repairs for boilers and heating-system piping will be expensive. Where no isolated plant is installed, live steam at low pressure is used, the reduced boiler pressure being available for kitchen, laundry and water-supply auxiliaries.

DESIGN OF THE HEATING SYSTEM

The heating system using forced hot-water circulation gives satisfactory service, but does not admit of the same control as a low-pressure steam-heating system. Special radiators require more space and cost considerably more to install. Steam-heating systems of the one- or two-pipe gravity-return type, will give fairly good results, but the vacuum-return-line system is thoroughly efficient, particularly where a light and power plant is installed in the building. Steam at pressures above or slightly below the atmosphere can be circulated, and the air in the steam and the water of condensation are automatically removed, thus eliminating air and return valves and all but one control valve.

The design of heating mains and returns depends somewhat upon financial considerations. An overhead heating main below the roof or around a service floor at the top of the house, with a pipe space for the returns between the ceiling of the public-room and guest-room floors, is an almost ideal arrangement, since it not only insures effective circulation, but keeps the large risers for heating the guest rooms clear of the public rooms on the lower floors.

The direct radiation for the public rooms is served from an auxiliary main and return in the basement or subbasement. In many hotels the heating mains and returns are all installed in the basement or sub-basement and the up-feed system used exclusively. This creates many structural difficulties and does not give as good results as the down-feed system.

Direct radiation on the outside walls between the windows will satisfactorily heat the public, guest and other exposed portions of a hotel and will take care of the wall and glass exposure and of any leakage caused by poor window construction. Hot-blast heating and mechanical ventilation is expensive, difficultly controlled, and does not take care of down-drafts and window leaks. An architect often designs a hotel, particularly the public rooms, without allowing for radiators of height, length and width for effective service. Windows running from the floor to the ceiling may be artistic, but from a practical point of view have no place in a hotel unless the owners will pay for a hot-blast system of heating.

Radiators in the public room are inclosed, more for appearance than service, but in the guest room inclosed radiators become receptacles for dust, cigars and cigarettes and materially increase the maintenance cost of the hotel. Since many guests object to heat at night in the sleeping rooms, all heating risers and returns should be covered with some efficient nonconducting material and inclosed either in the walls or by fireproof partitions.

Radiator control is of course an open question. Thermostatic control is no longer considered complicated or difficult to maintain, but its first cost is more than most owners will spend, regardless of the many advantages. A good vacuum-return valve requires little adjustment and is automatic under varying operating pressures. Its extra cost is often more than offset by the lower cost of the smaller pipes required.

A compromise for the thermostatic-control system is the so-called "modulating valve," with which a varying volume of steam is admitted to the radiator. Its cost is much less than that of the thermostatic, but is considerably more than that of the standard type of radiator supply valve. Since the modulated valve must be connected at the top, a hot-water radiator is required, resulting in an unsightly construction unless the connection is inclosed.

SOME HOTEL-VENTILATING PROBLEMS

The method of ventilating public rooms depends largely upon their architectural features. In rooms with flat ceilings the decorative detail should permit properly located ducts and registers of sufficient number and area. On the other hand, ventilation of a room with arched ceiling is a difficult and often a serious problem, particularly if space is not allowed between the false ceiling and beams for the register connections. It is then necessary to supply fresh air through a number of small ducts and register units, which create disagreeable drafts and hissing noises at the register. If the arched ceiling does not provide sufficient space for ventilation, a flat ceiling should be used. Independent fan units are preferable for large dining, banquet and ball rooms. The duct and register system can then be more effectively designed and is therefore easier and more positively controlled. Another advantage of the independent unit is that in case of trouble the ventilating service is only lost in a single room, which is not the case when a number of rooms are served from one large fan.

The ventilating apparatus for the laundry, kitchen and other rooms having heating apparatus should have liberal capacity. In these rooms the amount of air discharged should exceed the amount of incoming fresh air. Their exhaust, as well as that of the boiler, engine and pump rooms, should be powerful and direct. The insulation of engine- and boiler-room ceilings, while increasing the first cost, will materially reduce the ventilating requirements. In boiler and engine rooms it is necessary to install both fresh-air supply and foul-air discharge near the ceiling and to take care of proper distribution by elbows or nozzles designed for each particular room. It is good practice to install in the boiler room adjustable air nozzles with permanent elbows just above or to one side of the smoke breeching at the rear of the boilers.

AIR FILTERING AND COOLING

The fresh air should be thoroughly cleansed before being introduced into the building, tempered in the cold weather and humidified as conditions require. Air washers have generally replaced the dry filters formerly used. The air is tempered and reheated in passing over wrought-pipe coils or cast-iron stacks before it enters the fan. Thermostatic control for the tempered air is absolutely necessary for the ventilation of public rooms.

The air is cooled either by spray water or by a stack of brine coils built in the casing of the fans. Which system is the more effective depends largely upon local conditions and the results desired by the management. A good air washer will remove over 90 per cent. of the dust and dirt from the air, but will not remove the odors frequent in waterfront cities at certain times of the year. The only sure way to remove these is by the use of ozonators.

The fans and fan-motor sizes for both air supply and exhaust ventilation should be figured liberally. A fan direct-

*From the "Hotel Monthly," April and May, 1915.
†Consulting Engineer, New York City.

connected to a motor makes a more compact and quieter equipment than a belted outfit, but costs considerably more. The direct-connected fan also requires a special slow-speed motor, whereas the belted type can use a standard motor. The direct-connected type requires a less costly foundation and is less likely to transmit noise and vibration through the building.

COSTLY CHANGES IN VENTILATION

In recent years many hotels have been opened before the heating and ventilating system was completed, properly adjusted or tested. Instead of allowing for such conditions, quite frequently the system is pronounced a failure. After the system has been tested, there are too often changes in the air supply involving reconstruction or an entirely new system of mains and branches. The cost of these changes may easily be greater than that of the original system.

In a hotel recently built the inclosing of risers and the unnecessary inclosing of radiators in guest rooms cost over $35,000. This change made necessary the substitution of hydraulic-plunger elevators for those of the electric-traction type originally specified. The elevator change created extremely congested conditions in the sub-basement and cost over $125,000. Changes in ducts, heating mains, returns and branches in this hotel, involving additional expenditures from $25 to $2500, were common occurrences, all because sufficient space for the distribution of fresh-air supply, for the foul-air discharge shafts and headroom for main and branch iron ducts were not provided.

To insure an effective heating and ventilating system, efficient apparatus and devices should be selected, a responsible contractor should be chosen for their installation and the loyal support of all promoting the project should be given. Also, an essential requirement is a thoroughly competent engineer, whose duties should begin with the construction of the building. He should assist and coöperate with the architect and consulting engineer in the construction of the heating and ventilating system. He should not only give them the benefit of his practical experience, but should take over the plant, after its adjustment, test and acceptance, without the fault-finding of the operating engineer, hostile to everything he does not originate.

Qualifications of Montana Hoisting Engineers

By A. L. Street*

An act of the Montana legislature approved Mar. 8, 1915, requires all persons who operate electric and air hoisting engines, when used in lowering or hoisting men, except in elevators in buildings, and when of more than 25 hp., to obtain a license, after proof of qualifications and payment of fees. The text of the law is as follows:

Section 1. It shall be unlawful for any person to operate any electric hoisting engine, or any air hoisting engine over 25 hp., when either is used in lowering or hoisting men, except in operating elevators in buildings, without first obtaining a license therefor from the state boiler inspector or one of his assistants, as herein provided.

Except that in emergencies the provisions of Sec. 1657 of the "Revised Codes," relating to employment of unlicensed engineers, shall apply to the operation of the engine and machinery herein named.

Sec. 2. Application for such licenses shall be made to the state boiler inspector in the manner, and the same fee shall be charged therefor and for such license, as now required by law for obtaining a license to operate steam engines and steam boilers, and such license shall be given for a period of one year from the date of issuance thereof, and may be renewed in the same manner provided by law for the renewal of a license to operate steam engines or steam boilers; provided, that the state boiler inspector shall have the right to revoke any license issued under the provisions of this act for any of the reasons for which he could revoke a license to operate steam engines and steam boilers.

Sec. 3. A license granted under the provisions of this act shall entitle the holder thereof to operate any of the machinery named in Sec. 1 of this act, and the license shall specify on its face such machinery, but no license issued hereunder shall authorize or qualify the person to whom issued to operate a steam boiler or steam engine. Any person holding a license as a first-class engineer, authorizing him to operate steam engines and steam boilers, shall be deemed qualified to operate any of the engines and machinery named in Sec. 1 of this act without obtaining any license under the provisions thereof.

Sec. 4. Licenses issued under this act shall be divided into two classes, namely, first class and second class. No person must be granted a first-class license who has not taken and subscribed an oath that he has had at least three years' experience in the operation of at least one of the engines named in Sec. 1 of this act, and whose knowledge of the construction and operation is not such as to justify the belief that he is competent to take charge of and operate such machinery. No person must be granted a second-class license who has not taken and subscribed an oath that he has had at least two years' experience in the operation of at least one of the engines named in Sec. 1 of this act and whose knowledge of the construction and operation is not such as to justify the belief that he is competent to take charge of and operate such machinery.

Sec. 5. Any person to whom is granted a first-class license under the provisions of this act shall be deemed qualified to operate any of the machinery or engines named in Sec. 1 of this act, without regard to the horsepower thereof. Any person to whom is granted a second-class license under the provisions of this act shall not be permitted to operate any of the machinery named in Sec. 1 thereof, of a greater capacity than 100 hp.

Sec. 6. Any person who has regularly applied for a license under the provisions of this act and has been rejected may renew his application for such license within the time and in the manner prescribed in Sec. 1653 and Sec. 1654 of the "Revised Codes of Montana."

Sec. 7. Every person who operates any of the engines and machinery named in Sec. 1 of this act for which a license is required, without first obtaining a license as required by the provisions of this act, and every owner, employer or manager of any such engines or machinery who knowingly permits any unlicensed person to operate the same, or any person who violates any of the provisions of this act, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not more than $500 or by imprisonment in the county jail not more than six months, or by both such fine and imprisonment.

Sec. 8. All acts and parts of acts in conflict with this act are hereby repealed.

Sec. 9. This act shall be in full force and effect from and after its passage and approval.

*Attorney, St. Paul, Minn.

Smoke Abatement in Massachusetts

Continued success in the abatement of smoke is recorded in the thirtieth annual report of the Massachusetts Gas and Electric Light Commission, having supervision of stacks of stationary plants, locomotives and vessels in Boston, Brookline, Cambridge, Chelsea, Everett and Somerville. During the year ending Nov. 30, 1914, the board has continued its policy of promptly investigating all complaints received, giving notice of the resulting observations to the parties concerned, followed by further observations after a reasonable interval to permit correcting improper conditions. The inspectors have also continued to make, on their own initiative, periodic and systematic examinations and tests throughout the district, the number of such investigations far exceeding the number of complaints received. Last year 85 complaints came in, compared with 96 in 1913.

The board has given five public hearings on the smoke question and in two instances found it necessary to issue an order required as a preliminary to court proceedings. The latter were subsequently brought, resulting in the issue of restraining orders by the Superior Court and conviction and fines in the Municipal Court. As pointed out in previous reports, the law is not designed to prevent the emission of all smoke. A considerable amount may be emitted which does not fall within the proscribed grades on the Ringelmann chart, and may become annoying on days when the atmosphere is heavy or when the wind is blowing in certain directions. The board is convinced that there is room for further improvement in the emission of smoke by locomotives in and about roundhouses.

The work of the commission has included a persistent effort to show fuel users the importance of the law to their own interests and its workable character. While the board's practice has been to assist fuel users in adopting means of complying with its requirements, this has not relieved those controlling the operation of stacks from its observance. The results so far in diminishing smoke have been due not merely to the inspectors' vigilance but, in the words of the board, "to the active coöperation of those interested in the passage of the law, the various organizations of locomotive and sta-

tionary engineers and firemen and nearly all the larger fuel users."

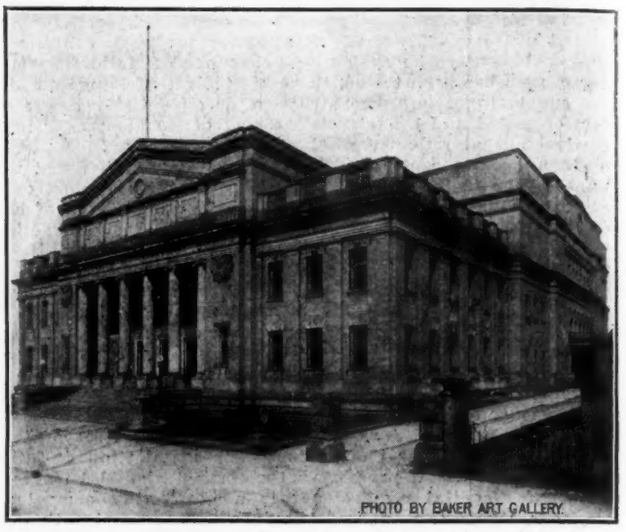
In 1914 the board made 28,126 recorded observations on stationary stacks, 12,903 on locomotives and 651 on marine stacks. The observations showing excessive emission were 934 from stationary stacks, 351 from locomotives and 49 from vessels. Out of a total of 41,680 observations, 1334 were outside the limit of legal emission. Last year there were 1225 violations noted out of 35,424 observations. In 1914 the percentages of observations in which violations were found were: Stationary stacks, 3.3; locomotives, 2.7; marine stacks, 7.6. Among the violations noted at stationary stacks, 786 were found to be due to the carelessness of those immediately responsible for their operation and 113 were due to overloading the plant. The stationary stacks upon which recorded observations show excessive emission are classified as follows: Public service, 21; manufacturing plants, 194; office buildings, 99. There were 261 stacks found after the first notice or visit of the chief inspector to have ceased emitting excess smoke, and the additional number of stacks so found after further notices or visits was only 41. But one stationary stack that had been found violating the smoke law had not ceased to emit excess smoke at the end of the year. The largest numbers of complaints were received in June and July, 13 coming to the office in each of these months.

Annual Convention N. A. S. E.

The National Association of Stationary Engineers will hold its thirty-third annual convention in Columbus, Ohio, Sept. 13-17. Headquarters will be at the Chittenden Hotel, all business sessions will be held in the Chamber of Commerce auditorium and the exhibits will be displayed in Memorial Hall. The state association will hold its convention Monday, but there will be only one session, so that all can welcome the incoming delegations.

During the convention Columbus wil hold its first fall festival, lasting four days and nights. This will include the annual style show of the Retail Merchants' Association, fêtes and pageants, a prosperity parade and numerous other features.

The local convention committee expects to surpass the enviable records made in the past by other convention cities.



MEMORIAL HALL WHERE CONVENTION EXHIBITS WILL BE DISPLAYED

MEMBERS OF THE CONVENTION COMMITTEE

Left to right, top row: C. W. Smith, H. E. Eichhorn, John Borden, C. C. Patton, Ernest Miller. Lower row: J. C. Weaver, T. E. McFadden, G. A. Barbee, L. C. Ziegler (Chairman), J. L. Sigrist, Joseph McCue.

The feature is to be an outing and field day at Indianola Park. Following is an outline of the program:

Monday, Sept. 13: 8 a.m.—Official registration at Memorial Hall for delegates, members and ladies; 8 a.m.—Registration at Chamber of Commerce Building for state officers and delegates to the Ohio state convention; 9:30 a.m.—Session of state association at Chamber of Commerce Building; meeting of trains by band and local committee; 8 p.m.—Reception by the national officers at Memorial Hall; 8:30 p.m.—Official opening of exhibits, Louis C. Ziegler, local chairman, presiding. Addresses by H. A. Pastre, president of the National Exhibitors' Association; Frederick L. Ray, national president; George J. Karb, mayor of Columbus; Walter H. Damon, national vice-president. Band concert. The exhibit hall will be open each day from 9 a.m. to 10 p.m. except Wednesday.

Tuesday, Sept. 14: 9:30 a.m.—Delegates and visitors meet at Chittenden Hotel and march to Memorial Hall accompanied by band; 10 a.m.—Opening exercises of the N. A. S. E. at Memorial Hall, L. C. Ziegler, chairman; invocation by Rev. John H. King; addresses by Governor F. B. Willis, of Ohio; National President Frederick L. Ray, Mayor George J. Karb, of Columbus; National Vice-President Walter H. Damon, President W. P. Tracy, of the Columbus Chamber of Commerce, and Past-National President James R. Coe; naming of the convention committees; adjournment for official photograph to be taken on the steps of Memorial Hall; 1:30 p.m.—First session of the association, Chamber of Commerce Building; 2 p.m.—Opening exercises of the Ladies' Auxiliary, Chittenden Hotel; 4 p.m.—Annual meeting of the Life and Accident Department, Chamber of Commerce Building; 8 p.m.—Theater party for all ladies registered and wearing badges; 10 p.m.—Smoker and entertainment given to delegates, exhibitors and members by the National Exhibitors' Association.

Wednesday, Sept. 15: Annual outing and field day at Indianola Park—races, swimming, ball games; exhibit hall open from 6 to 10 p.m.

Thursday, Sept. 16: 9 a.m.—Session of the convention; 9:30 a.m.—Session of the Ladies' Auxiliary; 11:30 a.m.—Annual memorial service; 2 p.m.—Session of the convention; 2:30 p.m.—Session of the Ladies' Auxiliary; 2:30 P.M.—Lecture to delegates and visitors; 8:30 p.m.—Entertainment given by National Exhibitors' Association.

Friday, Sept. 17: 9 a.m.—Session of the convention; 9:30 a.m.—Session of the Ladies' Auxiliary; 8:30 p.m.—Installation of officers and ball, United Commercial Travelers' Hall.

Recommends That Cleveland Take Over Private Company

According to press reports there is likelihood of Cleveland entering into municipal ownership on a still larger scale than heretofore by the acquirement of the properties of the Cleveland Electric Illuminating Co. Public Utilities Director C. W. Stage is said to be preparing a report recommending such a purchase through a municipal bond issue of $15,000,000, and it is expected that the question will come up for decision by the public at the next election.

The city already has lighting plants aggregating 25,000-kw. capacity, but is hampered by lack of proper distribution facilities. If it undertakes to install an adequate distribution system of its own in competition with the private company, much duplication will be involved; and one of the principal arguments in favor of taking over the latter is to avoid this duplication.

Electricians Now Licensed in Massachusetts

The Massachusetts Legislature has passed a bill establishing a board of examiners for electricians' licenses, with jurisdiction beginning Sept. 1. The board is composed of the chairman of the civil service commission, the metropolitan fire prevention commissioner, and the commissioner of education; it was organized July 1 and is to employ as a clerk a practical electrician who is a wage earner, a citizen of Massachusetts, and who has had at least ten years' experience in the installation of electric wiring and apparatus. Licenses are to be of two classes, "Certificate A" applying to master or employing electricians and "Certificate B" to journeymen.

The act prohibits the holder of a master's license from engaging in the actual work of installation. It is a question whether this provision would be held to be constitutional if interpreted to forbid the employer of a small number of wiremen from working with his own hands on a specific job. The act does not apply to the wiring, installation or repair of elevators, or to the private work of companies selling electricity, or to the work of transportation and communication companies. Municipal plants are also exempted from the provisions of the act up to the service switch, and the act contains full provision for licensing fees, yearly renewal of certificates, fines and imprisonment for violation.

Western Governors To Discuss Water-Power Legislation

Secretary Lane's policy for the leasing of water-power sites will be one of the principal topics for discussion at the conference of the governors of Western States to be held in Seattle in September. A bill embodying this policy was passed in the House at the last session of Congress, but died in the Senate, mainly through the efforts of a few Western senators headed by Smoot, of Utah, and Shafroth, of Colorado.

The bill was designed to prevent the extension of the monopoly of unused water powers and affected only power sites in the public domain. It provided that the Government should lease power sites to developing companies for 50 years, retaining the right to retake the sites and to take over the plants at their appraised value at the end of such a period. The Senators who opposed the measure urged that the power sites be either given to the developers in fee or turned over to the states for disposition. The adverse attitude of the last governors' conference was the main support of the opposition to the leasing bill in Congress. This opposition came mainly from Colorado and Utah, where the doctrine of state's rights was urged against any Federal leasing system. Governor Ammons of Colorado opposed the bills last year but his successor, Governor Carlson, is said to be more favorably disposed toward the leasing program, as is also Governor Spry of Utah.

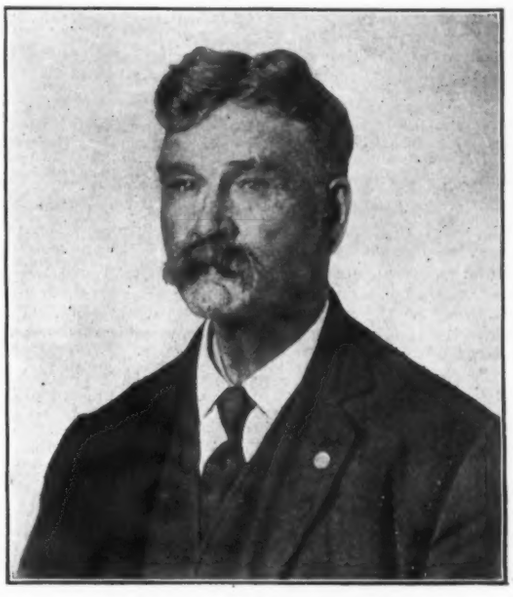
Since the adjournment of Congress advocates of this legislation believe that there is a trend of favorable opinion in the West, and that the governors' conference is likely to be in its favor this year. If the indorsement of the conference is secured, the Senate opposition at the next session of Congress, will represent, it is believed, only the water-power monopoly.

The Power Required to Raise Water may be approximated by multiplying the gallons per minute by the elevation in feet and dividing by 3300.

OBITUARY

WILLIAM KERR

William Kerr, who died recently in Chicago, operated the first turbine in that city at the Griffin Wheel Works in Kensington. He was born in Milton, Wis., in 1847 and served in the Civil War. In early life he was a traveling engineer for Swift & Co. and was also in the employ of Warren Webster & Co. He worked for the Pullman Co. for 28 years. During



WILLIAM KERR

part of this period he operated the famous Centennial engine, described in the July 13 issue of "Power." He also devised a vacuum system for heating cars, with which a train requiring several hours to heat by ordinary methods could be heated in fifteen minutes.

GEORGE RIPLEY STETSON

George Ripley Stetson died July 26 at the age of 78, in New Bedford, Mass. In early life he was in the employ of the O. F. Winchester Co., manufacturers of rifles and ammunition, but left that concern in 1873 to become superintendent of the Morse Twist Drill & Machine Co., of New Bedford. In 1890 he left the Morse Company to become president and general manager of the New Bedford Gas & Edison Light Co., an office he held until about three years ago. He then relinquished his active life with this company, but remained on the Board of Directors as chairman. Mr. Stetson was active in the civic and financial life of New Bedford, having served on the Water Board, and as president of the Board of Trade and of the New Bedford Coöperative Bank. He was made a member of the American Society of Mechanical Engineers in 1880 and served as one of its vice-presidents from 1898 to 1900.

PERSONALS

C. L. Brown has been appointed Chicago district sales manager of the Elliott Co., of Pittsburgh. His office is at 527 Monadnock Block, Chicago.

F. S. Healey is no longer with the engineering department of the John H. McGowan Co., builders of pumping machinery, Cincinnati, Ohio. His future plans are as yet unsettled.

L. G. Purtee has been appointed superintendent of power and shops of the Oklahoma Railway Co., Oklahoma City, with supervision over all shops, mechanical equipment, power, and substations. W. A. Fullgraf, formerly assistant chief engineer of the company, succeeds Mr. Purtee as chief engineer of power stations.

NEW PUBLICATIONS

STEAM BOILERS AND COMBUSTION. By John Batey. Published by Scott, Greenwood & Son, London, Eng. Cloth, 209 pages; 7½x4½-in.; illustrated; price, $1.50.

This little book is Volume XV of the Broadway Series of Engineering Handbooks. Chapters IV to and including VII are devoted chiefly to types of boilers. In these chapters there is practically nothing that is new or that is not common knowledge and found in nearly every book on the subject of boilers. The use of the chapters may be justified, however, as conducing to a better understanding of the balance of the book, which treats of combustion, movements of gases, boiler performances, etc. Being an English book, the Scotch and other British types of boiler are treated of and referred to chiefly.

VALVE GEARS. By Charles H. Fessenden, assistant professor of mechanical engineering, University of Michigan. Published by the McGraw-Hill Book Co., Inc., New York City. Cloth, 170 pages; 6x9 in.; 171 illustrations. Price, $2.

This volume is intended to be used as a text book rather than for reference purposes. The Zeuner and Bilgram diagrams are explained and used to illustrate typical valve-layout problems. An unusually complete discussion of port openings and passage areas is followed by a description of the construction and the method of laying out slide, riding cutoff, Corliss and poppet valve gears. Chapters on direct acting pump valves and on shaft governors are also included. A short chapter on valve setting gives directions for locating the valve by measurement and also a number of indicator cards illustrating faulty setting.

PRACTICAL APPLIED MATHEMATICS. By Joseph W. L. Hale, associate professor of engineering, Pennsylvania State College. Published by McGraw-Hill Book Co. Inc., N. Y. City. Cloth, 206 pages; 4½x7 in., 185 illustrations. Price, $1.

The book has been designed especially for use in mechanical trade schools. The subject matter covers arithmetic and elementary algebra. Particularly valuable are the sections on Mensuration, Use of Rules and Formulas, Use of Tables and Curves and on the Metric System of Measurements. A large number of problems (without answers) are scattered throughout the book, most of them being of a practical nature. Numerous rules are given for calculating lengths, areas and volumes. In fact, the whole subject of mensuration seems to be very thoroughly covered. It would seem that an explanation of the use of such elementary trigonometrical functions as the sine, cosine and tangent could have been included, but otherwise the book appears to be complete and should prove satisfactory for use as a technical textbook.

PRACTICAL SHOP MECHANICS AND MATHEMATICS. By James S. Johnson, superintendent of State Trade School, Bridgeport, Conn. Published by John Wiley & Sons, Inc. New York. Cloth, 130 pages; 81 illustrations. Price, $1.

This book is an attempt to cover the simpler applied mechanics and mathematics, as far as the two relate to actual shop conditions. The eight chapters are headed: Materials; Measures, Weights and Measuring Instruments; Pulleys and Belting; Tooth Gearing; Force and its Relation to Work; Forces; Stress and Strain; and Angle Measurements. In an appendix are given circumferences and areas of circles, squares and cubes and their roots and a table of trigonometrical functions. A large number of problems are given relating to the various apparatus described. In general, the solution of these problems depends upon simple arithmetic, but in the chapter on Forces a graphical method is employed. The last chapter gives a brief explanation of the meaning and use of the sine, cosine and tangent of an angle. The book should prove useful in classroom work to students who are grounded in arithmetic.

ELEMENTARY MECHANICS FOR THE PRACTICAL ENGINEER. By John Paul Kottcamp, head of the Mechanical Laboratory, Pratt Institute, Brooklyn, N. Y. Published by McGraw-Hill Book Co., Inc., New York. Size, 6x8½ in.; 181 pages; 85 illustrations. Price, $1.50.

This is a reprint in book form of the series of thirty lessons on Elementary Mechanics which formed a part of the "Engineer's Study Course" published in "Power." This division of the course was based on no higher mathematics than had already been covered in the course, including arithmetic, algebra, a little plane and solid geometry (particularly mensuration) and plane trigonometry. This earlier section of the course also is now published in book form under the title "Mathematics for the Practical Engineer." Taken together, the two books will afford the means of schooling oneself at home in all the essentials of these two subjects that an engineer needs to know. The treatment in the later volume is consistent with that in the other and in both series, five questions were given with each lesson and answered in the following lesson, immediately applying the principles as they were explained in examples that, as far as possible, were related to power-plant problems. Those who are not taking the subject up for the first time, but have grown a little "rusty" on it, will find the book an agreeable, easy means to "brushing up" on their mechanics. All in all, this book should prove quite as valuable an addition to the engineer's library as the one on mathematics, and even those who have the lessons in their back files of "Power" will find it more convenient to have them all together in book form. All three of the "Study Course" books, the third being "Fuel Economy and CO_2 Recorders," are of uniform size and binding, green cloth and gilt titling.

A STUDY OF BOILER LOSSES. By A. P. Kratz. Issued as Bulletin No. 78 of Engineering Experiment Station of the University of Illinois.

This bulletin presents a critical analysis of the data obtained from a series of 25 trials made on a 500-hp. Babcock & Wilcox boiler in the heating plant of the university. The boiler was operated under varying conditions of load and depth of fuel bed. Curves are presented and conclusions are drawn regarding the conditions necessary in order to secure the best continuous operation. In these tests gas samples were taken both at the bridge-wall and in the breeching, and a determination of the loss due to air leaking through the setting was made. A curve is also given which shows the percentage of excess air represented by the different amounts of CO_2 appearing in the gas. The heat balance has been subdivided so as to isolate and determine the amount of the several losses chargeable to the boiler, furnace and setting. Complete forms for calculating a series of boiler trials are given, and the corrections for differences in pressure and water levels at the beginning and end of a test are discussed. Tests were also made, using some samples of coal that had been exposed to the weather for about six years. An interesting fact brought out was that no difficulty was experienced in burning the weathered coal. It had deteriorated until it was of about the same composition and grade as the fresh Vermilion County screenings, and its steaming qualities compared favorably with those of the latter. Copies of Bulletin No. 78 may be obtained gratis upon application to C. R. Richards, Acting Director of the Engineering Experiment station, University of Illinois, Urbana, Ill.

TRADE CATALOGS

R. & J. Dick, Ltd., Passaic, N. J. Catalog. Balata belting. Illustrated, 20 pp., 3½x6 in.

Kerr Turbine Co., Wellsville, N. Y. Bulletin No. 54. Economy turbo-generators. Illustrated, 32 pp., 6x9 in.

De Laval Steam Turbine Co., Trenton, N. J. Catalog F. Centrifugal blowers and compressors. Illustrated, 64 pp., 6x9 in.

The Lagonda Mfg. Co., Springfield, Ohio. Catalog Z-1. Lagonda vibrator cleaners for return tubular boilers. Illustrated, 12 pp., 6x9 in.

The Titanium Alloy Mfg. Co., Niagara Falls, N. Y. Booklet. Titanium aluminum and other standard bronze castings. Illustrated, 32 pp., 3½x8½ in.

W. N. Best, 11 Broadway, New York. Catalog. Oil and tar-burning apparatus for marine, locomotive and stationary boilers. Illustrated, 32 pp., 6x9 in.

BUSINESS ITEMS

The Builders Iron Foundry, Providence, R. I., has recently been awarded the contract to supply 23 Venturi meters for measuring the supply to the Catskill Aqueduct distribution system. This company has previously supplied eleven meters for measuring the water in the aqueduct.

Same Here—That similar conditions and contentions prevail elsewhere as exist here is shown in the following, quoted from a paper recently read before the South African Institution of Engineers:

The Government Irrigation Department undertakes work for private individuals, at a fee which is considered inadequate by trained engineers in private practice, thereby depriving them of their legitimate share in the benefits of the country, and "spoon-feeding" a section that can well afford to pay for prospective improvements. If a person is lucky enough to be a land owner, surely his position would warrant payment for the improvement of his property. Government departments should confine themselves to propositions and schemes where public money and interests are concerned.